POWER

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The Efficiency of the Heat Engine

EVERY little while the assertion is made that the heat engine develops only ten to twenty per cent of the energy in the fuel, conveying the impression that present processes are extremely wasteful and that there is a possibility of an immense improvement when the real genius comes along.

Every little while an inventor arises to proclaim that the real genius has arrived and that he is it. He usually clears the ground by quoting the above assertion.

The assertion is scientifically correct, but it has its practical limitations.

A pound of water in a pond, the surface of which is one thousand feet above sea level, has, by reason of its elevated position, the possibility of doing one thousand foot-pounds of work in descending to the level of the sea.

But if the configuration of the country is such that a fall of only one hundred feet is available, it is impossible to get, even with a turbine of one hundred per cent efficiency, more than one hundred foot-pounds of work out of it by working it through that distance.

And that is the most that could be realized from it with perfect apparatus and processes by people constrained to live at that elevation.

To say that this perfect turbine gets out only ten per cent of the energy of the water may be true in a sense, and it is only in this sense that the assertion in regard to the heat engine is true.

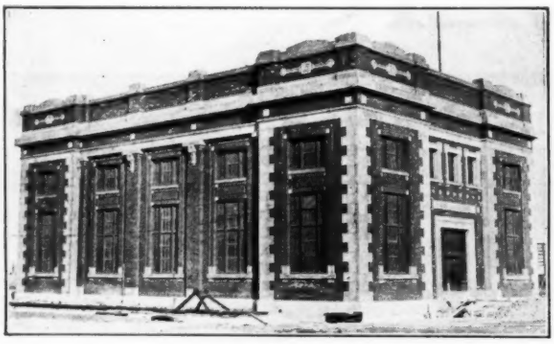
If all of the heat in a pound of coal—say 14,000 heat units—could be put into a pound of steam and that steam could be expanded down to absolute zero—the sea level of temperature—it would generate some 10,892,000 foot-pounds of energy.

And it would not make any difference whether the initial pressure and temperature of the steam were high or low.

But we live in a temperature zone of between zero and one hundred degrees Fahrenheit (460 to 560 degrees absolute). The lowest temperature to which we can expand steam, without the use of a condenser, is 212 degrees Fahrenheit, or 672 degrees absolute. With a condenser and plenty of cold water we can get it down to something like 60 or 70 degrees Fahrenheit (520 or 530 absolute), but this is the lowest level to which we can get our thermal tailrace.

We are in the same condition with regard to heat that the inhabitants of the country around the pond are with regard to the water. Either can do work only by falling, the water between levels of altitude, the heat between levels of temperature, and in both cases the lower level is fixed.

The inhabitants of the pond country can get more power out of the water by raising their dam and increasing the available head. So with the heat engine we can get more energy out of the heat by increasing the initial temperature and thus the available heat fall. We are getting, in the best practice, some 80 per cent of the heat of the fuel into the steam, and the best turbines get about the same percentage of the energy theoretically derivable from the fall of the steam through the available temperature range into electrical energy. The best steam practice, therefore, realizes upward of 60 per cent of the ideally attainable. The best internal-combustion engines yield some 60 per cent of the energy available from their temperature range, but that available heat is greater on account of their huge initial temperature, so that their thermal efficiency is greater than that of the steam engine. t is upon this basis, and not that of an impossible fall to the zero of temperature, that the performance of the heat engine and possible improvements in its efficiency should be judged.



A 2,500-Kva. Diesel-Engine Plant for Stand-by Service

By HOMER I. STEFFA, M. E.*

THE Calumet Station of the Chicago Sanitary District is equipped with four 750-b.hp. two-stroke cycle Diesel-engine generator units. Plant insures breakdown service for sewage-pumping stations.

THE particular advantages of the Diesel engine for stand-by service is receiving general recognition. Owing to the elimination of banked fires and other conditions that necessarily exist in a plant that must be ready to deliver its full capacity on short notice, the reduced operating charges more than offset the slightly increased overhead expense.

A stand-by plant of particular interest is the Calumet Power Station of the Chicago Sanitary District. The general power supply for the motor-driven centrifugal sewage pumps at the Calumet and Ninety-fifth Street sewage stations is obtained from the Sanitary District's hydro-electric plant at Lockport, Ill. This power is carried over a 30-mile 44,000-volt three-phase 60-cycle transmission line and is then stepped down to 12,000 volts, the low-voltage lines totaling about 15 miles. As the sewage pumping stations are required to operate at all times, the long transmission line could not be entirely depended upon, particularly in times of severe storms. Since it is quite essential that the pumps operate at their maximum capacities at such times in order to handle the storm flow in the sewers, a stand-by plant was found to be a necessary part of the sewage system.

A Diesel-engined plant was decided upon after a thorough study of all types of prime movers that were at all suitable for this service. The decision in favor of the Diesel engine was due to its many advantages for stand-by service—it can give full power quickly, is self-contained and has a very high thermal efficiency.

Estimates showed that the Diesel plant would cost approximately 10 per cent more than a condensing steam-turbine plant of like capacity, but that the annual charge against the Diesel plant would be only about one-third the annual charge against the steam-turbine plant. One of the important items of this charge in favor of the Diesel engine is the saving of fuel for a

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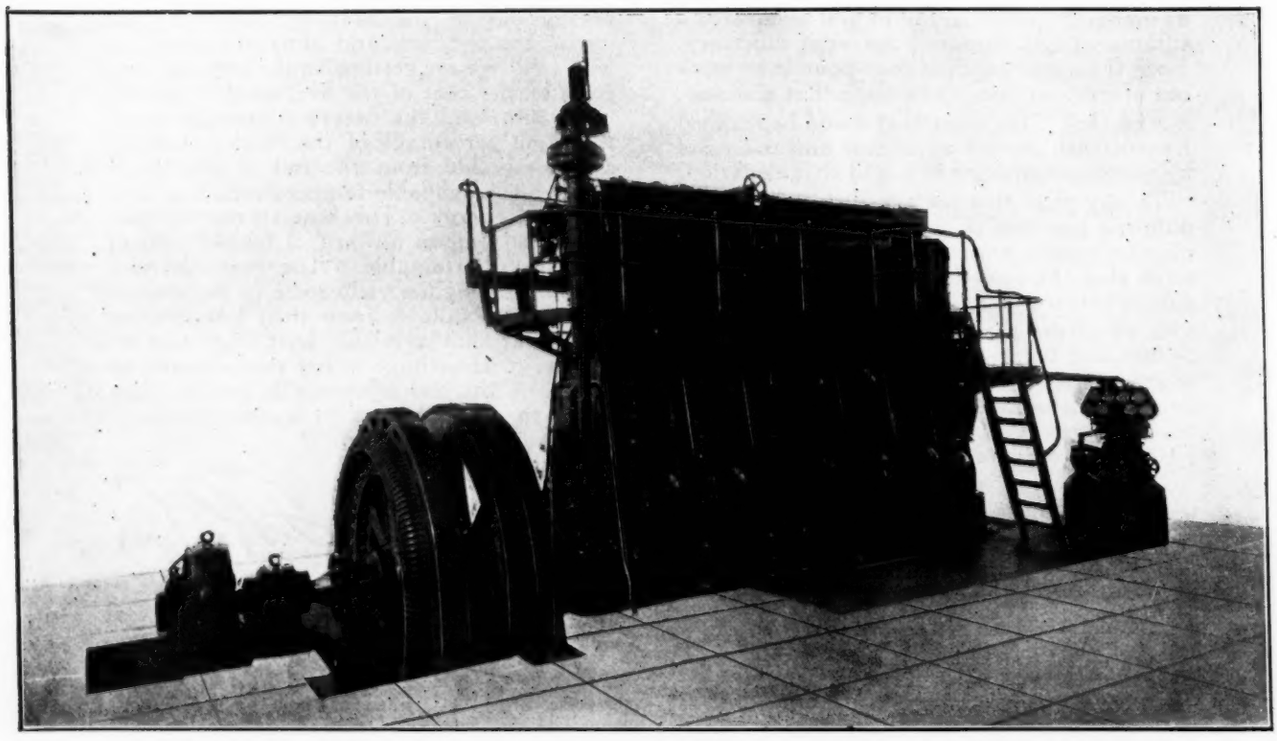

FIG. 1. SEVEN HUNDRED AND FIFTY BRAKE HORSEPOWER BUSCH-SULZER TWO-CYCLE DIESEL

stand-by plant. It is estimated that the coal for banking will approximate 0.05 lb. per sq.ft. of heating surface per hour, and with the Diesel engine no fuel is used save when a load is being carried. The lowered operating costs when the Diesel engines are running are also attractive and more than offset the slightly increased first cost.

The building, which is shown in the headpiece, is an imposing structure of monumental design throughout. The exterior walls are of vitrified pressed brick trimmed with light gray Indiana limestone from the Bedford quarries. The base course around the entire building is of light pink granite. Interior walls are lined with salt glazed pressed brick of two shades in paneled effect with terra cotta trim. The main, or engine-room, floor is finished throughout with red tile. The substructure of reinforced concrete is heavy in design. A continuous concrete slab seven feet thick extends under the building, into which the foundations proper of all four units are keyed. The fresh-air intake duct leading to the scavenging air pumps is cast into this slab with a branch leading to each engine.

The power units consist of four 750-b.hp. 180-r.p.m. Busch-Sulzer Bros. vertical two-stroke-cycle, type C, Diesel engines, each direct-connected to a 625-kva. 60-cycle three-phase 2,300-volt General Electric generator. The generator, flywheel and 16-kw. 125-volt exciter are mounted on an extension shaft which is coupled to the engine crankshaft just within the engine frame. This shaft is supported by the engine end bearing and an outboard bearing, as shown in Fig. 1.

The guaranteed fuel consumptions of the engines were as follows: Full load, 0.47 lb. per b.hp.; three-quarter load, 0.49 lb.; one-half load, 0.53. On the test floor the type C engine showed a fuel consumption much below these guarantees. The heat balance of the units works out as shown in Table I on the basis of an input of 1,000,000 B.t.u.

TABLE I. HEAT BALANCE OF 750-H.P. DIESEL-ENGINE SET

	B.t.u.	Per Cent of I. Hp.	Per Cent of Supply
Input	1,000,000	....	100
Cooling water	341,000	....	34.1
Exhaust	233,000	....	23.3
Indicated work	426,000	....	42.6
Work of compression	34,591	8.12	3.4
Work of scavenging pumps	30,373	7.13	3.0
Friction	62,325	14.6	6.2
Brake horsepower	298,830	70.15	29.89
Electrical losses	22,413	....	....
Net energy at switchboard	276,426	....	27.64

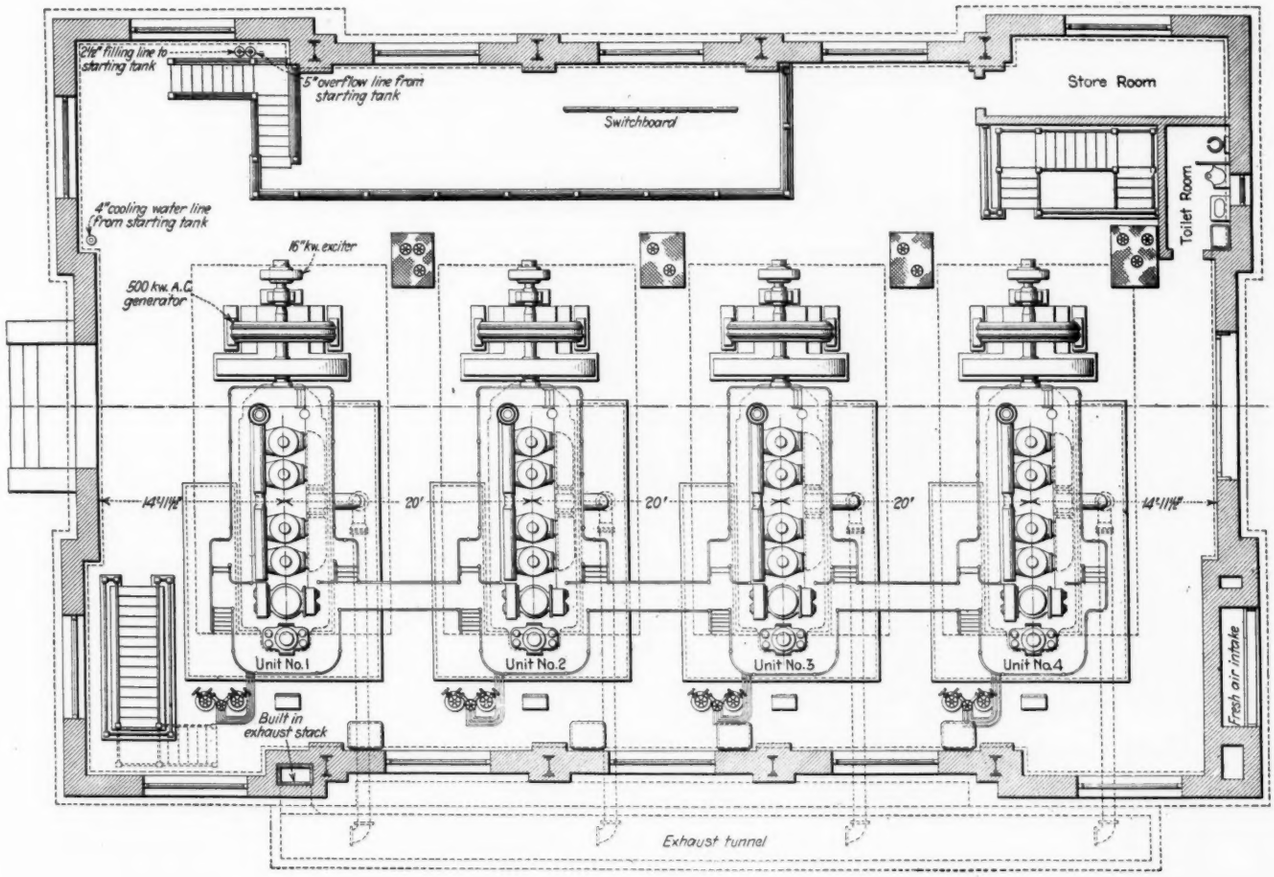

FIG. 2. PLAN OF CALUMET STATION

These four units are set in a row with a working aisle between each two units and along the walls. The platforms by which access is had to the operating gear are connected by bridges. In this way the operator may pass from engine to engine without descending to the floor level.

With the exception of the air starting bottles and the control board, Fig. 5, all the auxiliaries such as fuel pumps, lubricating oil tank, water pumps, etc., are in the basement. The plant, consequently, has a decidedly open and attractive appearance.

Fuel oil for the plant is stored in four 10,000-gal. underground concrete tanks outside the building, which are served by a railway track for tank-car delivery.

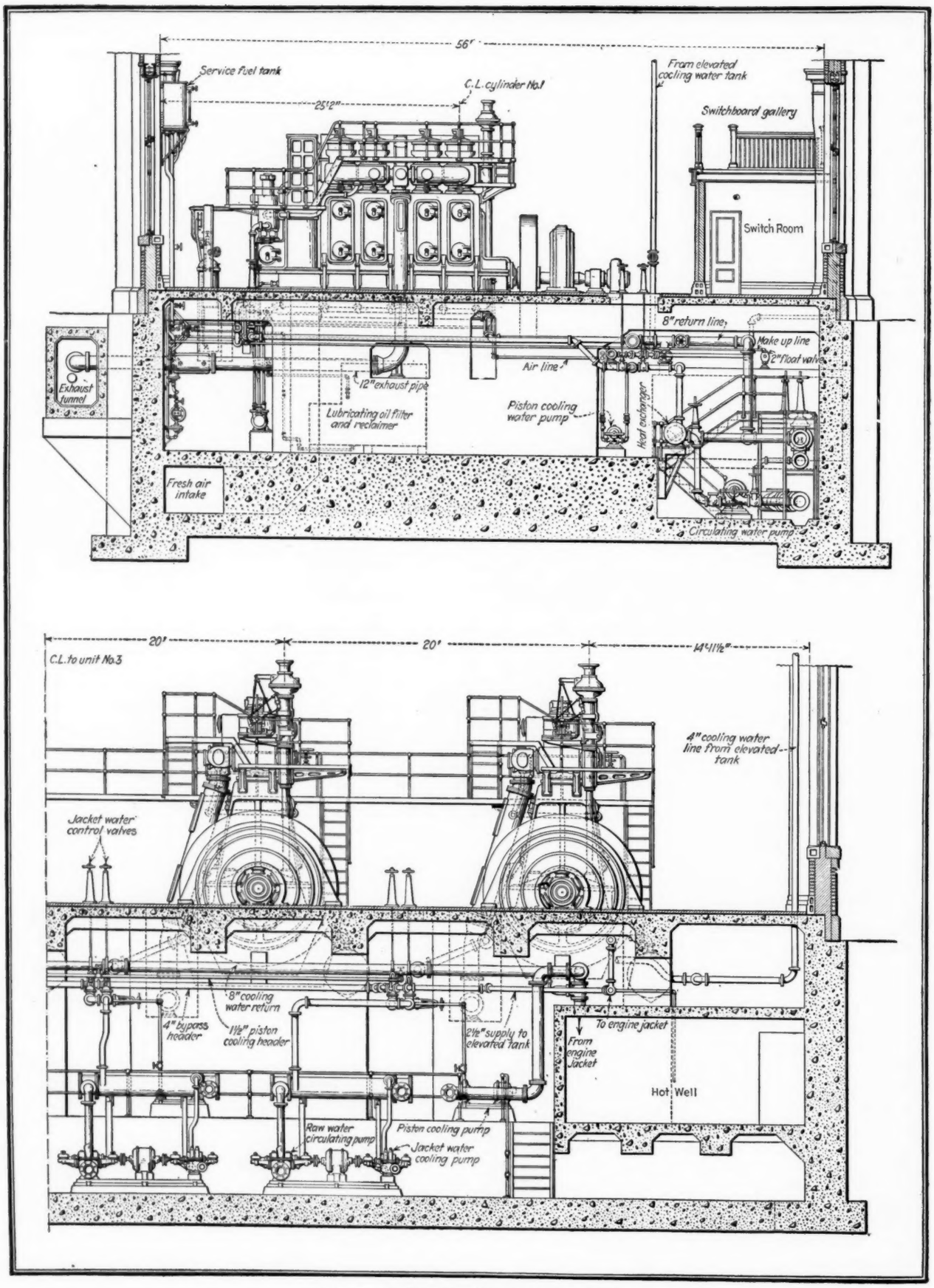

FIG. 3. CROSS-SECTIONS OF STATION

Each tank has two manholes so that it can be properly aired when it becomes necessary for it to be cleaned. A concrete trench for accommodating filling pipe lines is constructed over the tops of the tanks. Piping in this trench is so arranged that two tank cars can be unloaded at once. Valves are so located in the filling pipe line that oil can be delivered to any one tank or group of tanks at the same time. Provision for heating tank cars in cold weather is obtained by a steam supply line from the station's heating plant, which extends the full length of the filling-pipe trench.

On the station wall about opposite each engine there is mounted an auxiliary fuel-oil tank from which fuel is supplied by gravity to each engine's fuel pump. Each auxiliary fuel tank has two compartments, one of about 100 gal. capacity for heavy fuel oil, and the other about 15 gal. for light fuel or kerosene.

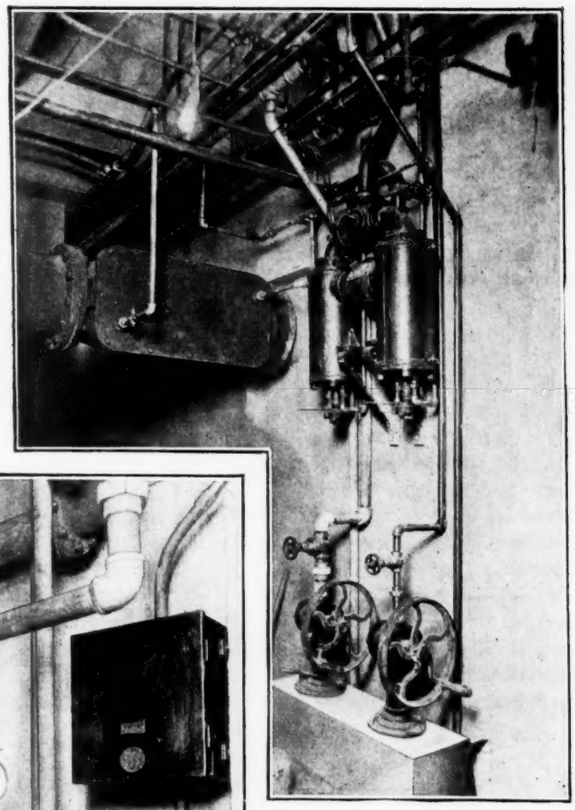

FIG. 4. FUEL OIL PUMPS

At the right are shown the two motor driven fuel oil pumps. Oil is drawn from the underground tanks by these rotary pumps and delivered to the small tanks above the engines. Pumps are hand regulated and the overhead tanks are provided with overflow connections to prevent flooding.

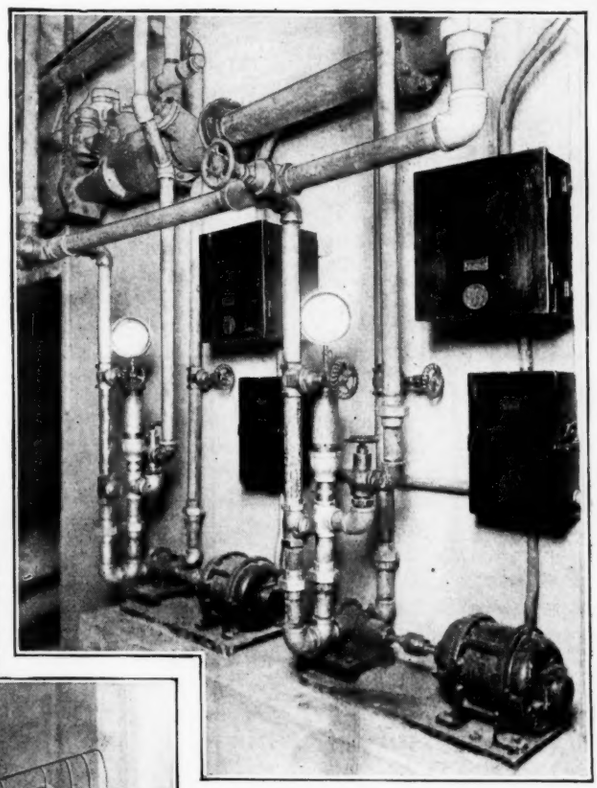

FIG. 6. FUEL TEMPERER

The illustration above shows the horizontal exhaust line provided with a water heater. The water circulating through the heater coils passes to the oil strainers, where the oil is warmed by the hot water. The arrangement enables the viscosity of the fuel oil to be regulated at will.

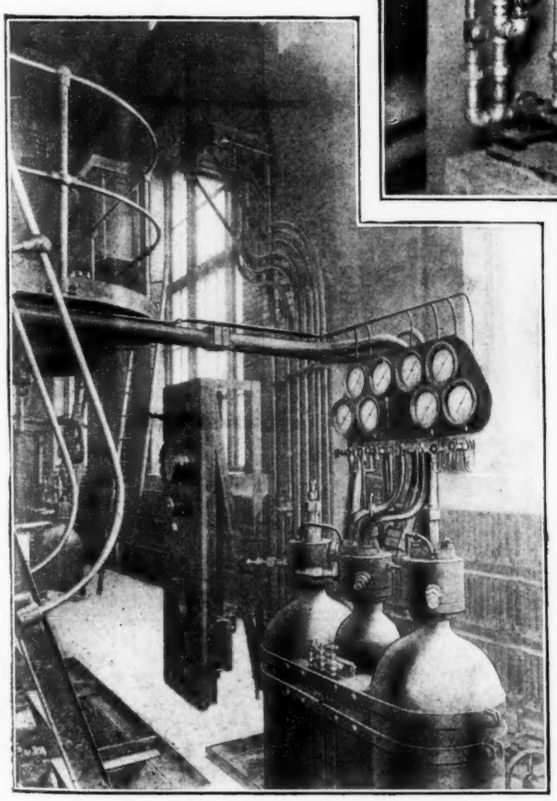

FIG. 5. ENGINE CONTROL BOARD

Fuel oil to these auxiliary fuel tanks is supplied by two motor-driven rotary-type oil pumps each with a capacity of 10 gal. per min., Fig. 4. One of these pumps will be held as a spare at all times. There is also provided for each engine supplementary hand-operated fuel-oil pumps.

All kerosene is handled by hand-operated rotary pumps, located in the basement, Fig. 6, from a 300-gal. steel storage tank located in an underground vault outside the station structure. All auxiliary fuel tanks are equipped with overflow connections and drains whereby excess fuel oil or kerosene is returned to the main underground storage tanks.

The fuel-oil piping is so arranged that fuel oil may be transferred from any one or more storage tanks to another or other tanks, the motor-driven fuel-oil pumps being used to make the transfer.

Tempering of the fuel oil is provided by a positive circulating hot-water system. A water heater constructed of copper

coils in a cast-iron shell is installed in the exhaust header of each engine. A water-supply connection is taken from each engine cooling water line to its heater. Distributing pipe lines are extended from the heaters to the fuel-oil strainers and auxiliary fuel-oil tanks

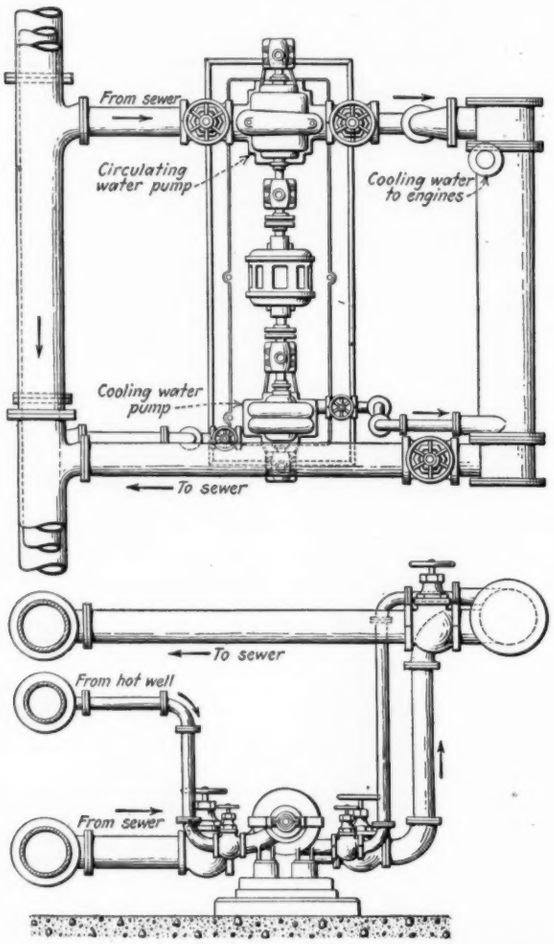

FIG. 7. ENGINE COOLING WATER HEAT EXCHANGER

which are equipped with heating coils and to the heating coils located around the suction pipe in the underground fuel-oil storage tanks. The hot-water distributing lines are run directly under the fuel-oil lines in the building and are incased in a common pipe covering, thereby supplying heat to the fuel-oil piping system.

The oil temperer will be used only in the event that a low-gravity oil is purchased, which will be done only when there is a considerable price advantage in the heavier fuel. The design of the exchange is such that by hand regulation sufficient hot water may be circulated to give any desired final temperature to the fuel oil regardless of the initial temperature.

Engine Cooling System

Cooling of the engines is accomplished by a closed cooling and circulating water system. Each engine is provided with a complete set of auxiliary apparatus for this purpose, the sets being so interconnected that any cooling and circulating set can be used with any of the four engines. A set of this auxiliary apparatus consists principally of a double centrifugal pump unit with a motor having its shaft extended at both ends mounted between them as a common prime mover, a heat exchanger and a booster centrifugal pump for handling the piston cooling water and necessary piping.

Circulating or raw water, which, normally, will be river water, is drawn from a storm sewer by the circulating-water pump, a basket strainer being placed in the suction line. The water is circulated through the tube side of the heat exchanger, Fig. 7, and out to the discharge sewer.

The engine cooling water is taken from a hotwell in the basement, shown in Fig. 3, by the cooling-water pump which is the second element of the double pumping unit, and is forced through the shell side of the heat exchanger, and then through the cooling-water passages of the engine. The cooling water upon leaving the engine flows by gravity back to the hotwell, where it is again circulated through the cooling system. A small booster centrifugal pump takes a part of the cooling water as it leaves the heat exchanger and forces it through the cooling passages of the engine pistons, the water returning to the hotwell by gravity.

Auxiliary Water Tank

At the time of starting a unit, when the total plant is down, the engine cooling water is supplied from an elevated storage tank installed just under the roof and about thirty-five feet above the engine-room floor. This tank has a capacity such as will supply one engine with cooling water for about fifteen minutes. As soon as

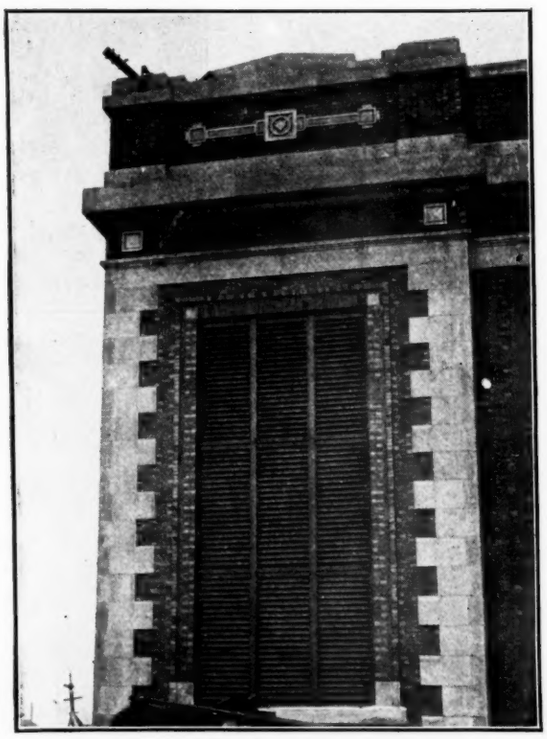

FIG. 8. AIR INTAKE FOR ENGINES

electrical energy is generated by the power unit, the general cooling-water system previously described is put into operation and the supply from the elevated storage tank is shut off. The tank is refilled by one of the cooling-water pumps, the end of the filling pipe in the storage tank being provided with a float valve for maintaining a fixed water depth. The tank also has an

overflow pipe which returns any excess water to the hotwell in the basement.

It is estimated that the quantity of cooling water to each unit will be around 5,400 gal. per hour. Of this amount 1,000 to 1,200 gal. will be circulated through the pistons. These amounts are based on an incoming temperature of 85 deg. and an outlet temperature of 140 deg. F. Automatic control of the cooling water has not been attempted since there are a number of variables such as character of fuel used, load carried, etc., which must be considered in regulating the cooling-water flow.

Air for the scavenging pumps and air compressors is taken from outside the building through a false window, Fig. 8, which is covered with a fine-mesh copper screen. The screen is protected by louvers on the outside against storms and foreign matter. A duct built into the building wall and substructure concrete work leads from the screen to under the basement floor and to each engine foundation, which has cast in it a duct of the air intake of each engine.

That portion of the air intake duct under the basement floor is provided with manholes, one at each engine foundation for access into the duct. The manholes are equipped with double covers, the inner one of which is dust-tight and is provided with a locking device, thereby eliminating all chance of foreign substances entering the air pumps.

Exhaust Connections

Exhaust gases are carried by a cast-iron pipe exhaust header from each engine to an underground tunnel outside the building. As stated previously, there is installed in each header a water heater for serving the fuel-oil tempering system. A sliding expansion joint is provided in each header, as the section that passes through the building wall and into the exhaust chamber is grouted in tight.

The exhaust tunnel is built of reinforced concrete and extends alongside of the building approximately its full length and is supported by reinforced-concrete brackets from the substructure wall. It is made with a large volume with the idea of reducing the temperature and pressure of the exhaust gases. The inner surface of the chamber is plastered with a one-half inch thick layer of master builders' plaster. Manholes are provided in the top of the chamber for access. Several tongue-and-groove expansion joints packed with asbestos girdle the chamber to take care of expansion and contraction.

The exhaust stack is of a novel design and is built into the building wall. It is made of precast sections of reinforced concrete 2½ in. thick and about 18 in. long, rectangular in shape and the full size of the cross-section of the stack. The sections were set in place and carried up with the masonry work of the building structure. An asbestos sheeting is placed around the exterior of the precast sections so as to allow freedom of expansion and contraction in its length and also act as an insulation between the stack and the brickwork of the building wall. The interior of the stack is lined with a half-inch coating of master builders' plaster troweled smooth.

Each engine is provided with a control station for controlling the operation of auxiliary apparatus and handling certain features of general operation. The panel is made of Monson slate with its back inclosed in a sheet-iron housing. Installed upon the panel are push-button control switches for the engine-cooling and circulating-water pump, piston-cooling water pump and the fuel-oil pumps. There is also installed upon each panel a pyrometer indicating gage, and a pyrometer switch with four points and off. Each switch point is in connection with a thermocouple installed in the exhaust port from each cylinder for taking temperatures of the exhaust gases. Each panel is also equipped with a double-pen recording thermometer for indicating graphically the temperature of incoming and outgoing engine cooling water.

Engine Control Boards

Starting and injection air flask groups, Fig. 5, are provided at each engine and are interconnected. The groups are installed in pockets built into the engine-room floor, which brings the valving of the air flasks within easy reach from the floor. Mounted across the top and to the back of each group is a gage board upon which is mounted the indicating pressure gages for lubricating oil, piston and jacket cooling water and the various air stages and services. This enables the operator to have full knowledge of operating conditions.

The switchboard and its apparatus is installed along one side of the station. The bus structure, oil switches, potential, current and power transformers, motor-operated generator field rheostats and miscellaneous switching equipment are installed in a room the top of which is constructed as a gallery and upon which the switchboard proper is mounted. The switchboard panels are made of genuine black Monson slate rubbed to a smooth finish. The switchboard consists of seven panels and one swinging-bracket panel of which four are for the generators with exciter control on the same panel; two feeder-circuit panels and one station-service panel for station lighting and power circuits.

EQUIPMENT OF CALUMET POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Diesel engines	Two-cycle	750-hp	Drive generators	180 r.p.m	Busch-Sulzer Bros.—Diesel Engine Co.
4	Generators	Engine type, dir. con.	650-kva	Power generation	2,300-volt, 3 phase, 60-cycle	General Electric Co.
4	Exciters	Engine type, dir. con.	16-kw	Excitation to generators	115-volt d.c.	General Electric Co.
4	Pumps	Centrifugal	650-g.p.m., 30-ft. head	Circulating or raw water	Driven by G. E. Co. 15-hp. motor as double pump unit	American Steam Pump Co.
4	Pumps	Centrifugal	110-g.p.m., 90-ft. head	Engine-cooling water		
4	Pumps	Centrifugal	20-g.p.m., 81-ft. head	Piston-cooling water	Driven by G. E. Co. 2-h.p. motors	American Steam Pump
4	Heat exchangers	Special baffle	160-sq.ft	Cool engine-jacket water	110 g.p.m. from 135 to 85 deg. F.	Sims Co.
1	Water strainer	Basket	12-in	Circulating water	530-sq.in. effective area	Elliott Co.
1	Bilge pump	Centrifugal vertical shaft	3-in	Drainage water	100 g.p.m., 20-ft. head	Yeomans Bros. Co.
2	Pumps	Rotary	1½-in	Fuel oil	10 g.p.m., 30-ft head	Exeter Machine Works, Inc.
1	Lubricating oil reclaimer	Electric heater	750 gal. per batch	Purifying lubricating oil	8-hr. cycle	Richardson-Phenix Co.
	Valves	Gate	All sizes	Fuel and lubricating oil, kerosene and water	Low to medium heads	Chapman Valve Mfg. Co.
	Floor plate	Anti-slip		Galleries, floor plates and stair treads		American Abrasive Metals Co.

Installation of all power-plant equipment and manufacture of special parts. Robert Gordon, Inc., Switchboard and wiring, Hatfield Electric Co.

Locating Faults in Direct-Current Armatures—Short-Circuits in Parallel Windings*

Methods of Locating Short-Circuits in Series Windings with a Low-Reading Voltmeter—How To Tell if the Fault Is in the Coils or Commutator

By B. A. BRIGGS

WHEN testing an armature for faults by passing a current through the winding and taking readings with a low-reading voltmeter on adjacent commutator bars, care must be exercised in locating the position of the current-carrying contacts on the commutator. In the article dealing with "Short-Circuits in Parallel Windings," in the Feb. 21 issue, it was shown that in all cases with a single-parallel winding the brushes could be located on opposite ends of the commutator's diameter, as in Fig. 3, irrespective of the number of poles for which the armature may be wound. In a series winding this is not the case and the brushes must be located one pole space apart, as in Fig. 1. In the figure, starting from segment 7 there are two circuits through the winding. One of these is from segment 7 through coil 1 to *a* and *a'* and to segment 20, through coil 14 to segment 8, through coil 2, etc. until the circuit ends on segment 13. The other circuit is from segment 7 through coil 13 to segment 19, then through coil 25 to *j'* and *j* to segment 6 and then through coil 12, etc., until the circuit is completed on segment 13. These two circuits include all the coils. On account of there being a total of 25 coils, there is one more coil in one path than there is in the other, but this will have very little effect so far as the value of the current in each path is concerned, therefore it may for all practical purposes be considered that equal current flows in each path.

Suppose that the brushes are set on the opposite ends of the commutation's diameters as for a parallel winding; for example, on segments 7 and 19 in Fig. 1. Coil 13 connects to segments 7 and 19, therefore this coil is all that would be in one circuit through the armature, while the remaining 24 coils would be in series in the other path. As a result, practically all the current supplied through the lamps to the winding would flow through coil 13 and only a very small part through the other 24 coils. Under this condition no reading or only a very low reading would be obtained when the voltmeter was connected to the segments to test for faults. From the foregoing it is evident that the brushes on the commutator must be located one pole space apart on a series winding, as in Fig. 1, to get the right distribution of the current in the coils to make the tests. This means that the brushes must be spaced 90 deg. on a 4-pole, 60 deg. on a 6-pole and 45-deg. on an 8-pole machine.

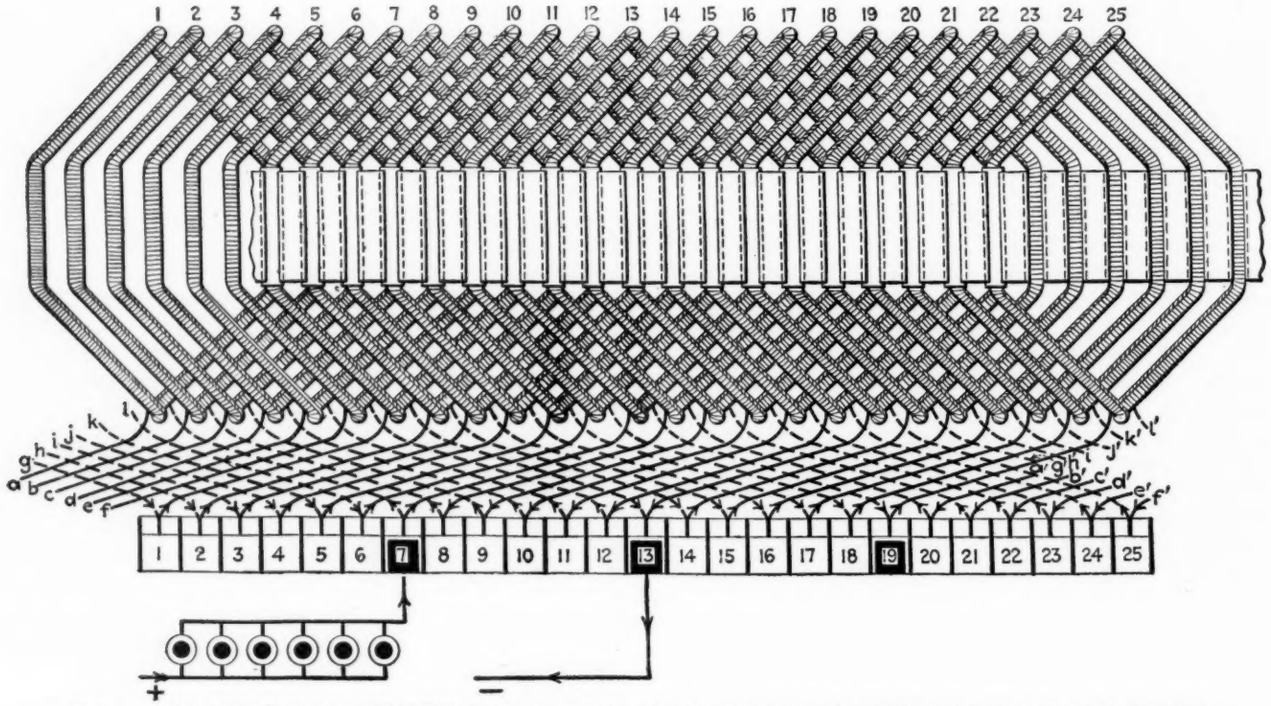

FIG. 1. CONNECTIONS FOR SENDING TEST CURRENT THROUGH SERIES-CONNECTED ARMATURE WINDING

After the armature has been connected to the circuit as in the figure, the next step is to take readings on adjacent segments on the commutator, as indicated on segments 16 and 17, Fig. 2, and note the deflection. A low reading indicates a short-circuit and a high reading an open-circuit or high resistance connection. The current in the winding should be adjusted until the needle

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is deflected about halfway across the scale for normal deflection. When the millivoltmeter is connected to adjacent segments, as on bars 16 and 17, Fig. 2, the instrument is connected to the terminals of two coils in series. Starting from segment 17 and following the connected to segments 16 and 17, Fig. 3—it is known at once that the short-circuit must be between the segments to which the coil connects or in the coil itself, since the two leads of the coil connect to adjacent segments. For example, in Fig. 3, if a low reading was

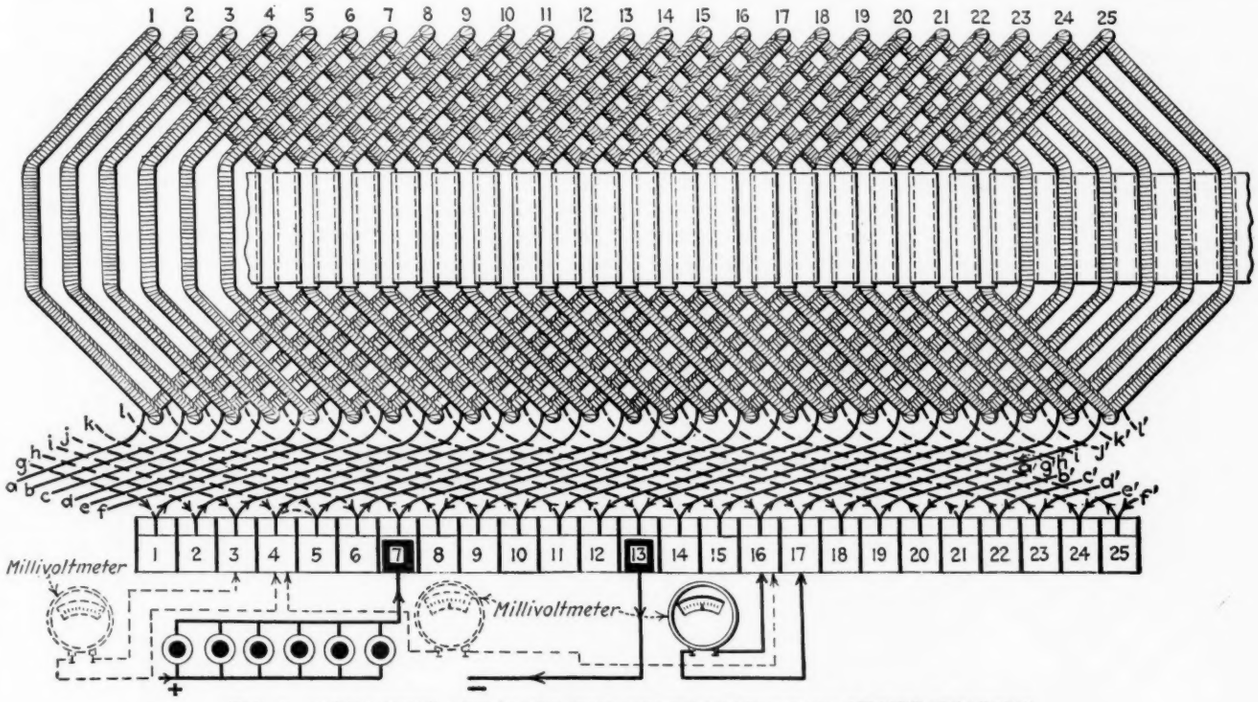


FIG. 2. HOW TESTS ARE MADE FOR SHORT-CIRCUITS IN SERIES WINDING

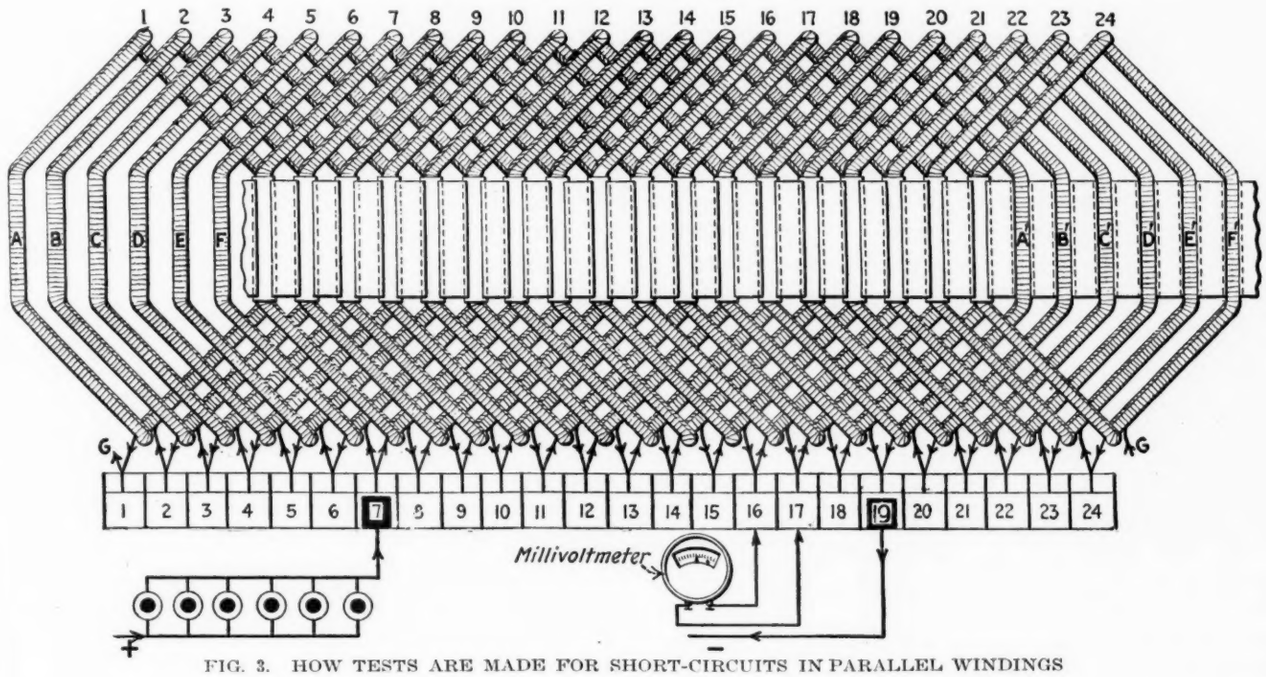


FIG. 3. HOW TESTS ARE MADE FOR SHORT-CIRCUITS IN PARALLEL WINDINGS

circuit through coil 23 to j' and j, to segment 4, then through coil 10, the circuit will end on segment 16. This gives the coils in series, so that the reading on the millivoltmeter is the voltage across two coils, instead of one as in the parallel winding, Fig. 3.

When the millivoltmeter gives a low reading on a parallel winding—for example, when the meter is connected to segments 16 and 17, it would be known that a short-circuit was in coil 16 or between segments 16 and 17. Therefore, the actual location of the defect can be easily determined, as explained in the article in the issue of Feb. 21.

Assume that a test was being made around the com-

mutator in Fig. 2 and that when the meter was connected to segments 14 and 15 a one-half scale deflection was obtained, likewise when connected to segments 15 and 16. However, when the meter was connected to bars 16 and 17 the deflection was only about two-thirds normal. This would indicate that there was a short-circuit in some part of the circuit to which the millivoltmeter connected. Now this involves more than might be at first suspected. Suppose that there was a short-circuit between segments 4 and 5, as indicated by the dotted line. One circuit from segment 6 is through coil 12, to segment 18, through coil 24, to k' and k to segment 5. Now, if there were no fault between segments 4 and 5, the circuit would be from segment 5 through coil 11 to segment 17. However, with a short-circuit from segments 4 and 5 the circuit is also from bar 5 to 4, then through coil 10 to segment 16; this leaves segment 17 only one coil would be in circuit and the meter would read about one-half normal or about one-quarter scale. From the foregoing it is seen that if the meter reads between normal deflection and one-half normal, it is an indication that the defect is in a coil; if less than one-half normal, then the defect is probably between two adjacent segments, although this does not necessarily hold true in all cases. Of course the foregoing pertains to 4-pole machines. In a 6-pole machine there are three coils in series between each pair of adjacent segments, consequently if a coil was completely short-circuited out of the group it would reduce the reading of the meter only about one-third from normal.

In Fig. 2, assume that when the millivoltmeter was connected to segments 16 and 17 it read about two-thirds normal deflection, and that when readings were taken on segments 17 and 18 the meter read normal again. It would then be known that some defect was in the circuits connected to 16 and 17, but as pointed out in the foregoing, there are a number of places where this defect might be. Therefore, it is desirable to make further tests to determine the exact location of the fault. In the winding under consideration the pitch of the coil leads on the commutator is 12 segments or 1 and 13. Calling segment 16 number 1 and counting to the left, 13 locates the other lead of one of the coils that connects to segment 16. By taking millivoltmeter readings from the segments around this location, the low reading should be obtained again. In this case assume that the same reading that was obtained on segments 16 and 17 is also obtained on segments 3 and 4. The circuit through the two coils in series which connect to segments 3 and 4, is from 4 through coil 10 to segment 16 through coil 22 to i' and i to segment 3. This includes coil 16 as in the group that connects to segments 16 and 17, therefore the conclusion could be drawn that the defect is in coil 16, since this coil is in circuit in both cases. However, on an actual winding it would not be very easy to see this, therefore a more convenient

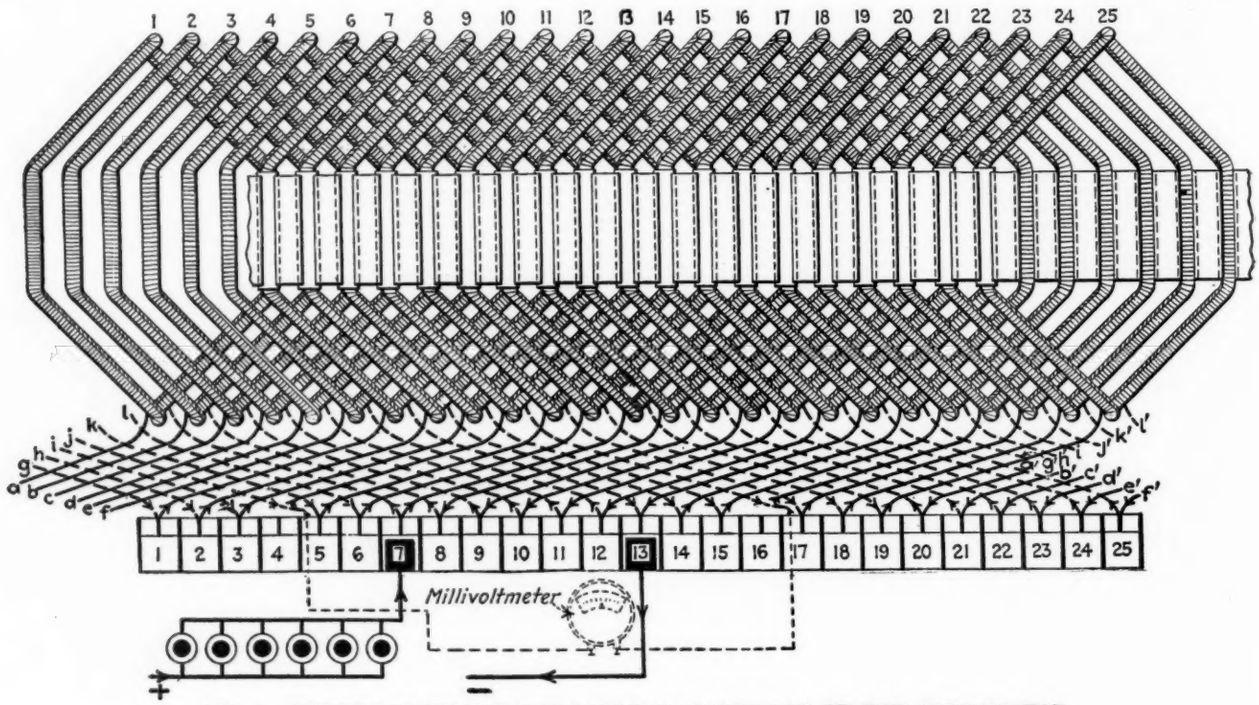


FIG. 4. TESTING TO FIND IF THE FAULT IS IN THE COIL OR THE COMMUTATOR

at a lower potential than would be the case if the defect were not between segments 4 and 5. From this it is seen that a fault between segments 4 and 5 will produce a low reading on the millivoltmeter when it is connected to segments 16 and 17, consequently, there are four places that the defect may be for a low reading on the millivoltmeter when connected as in Fig. 2. These are in coils 10 or 23, or between segments 16 and 17 or 4 and 5.

The next problem is then to locate the actual defect. If the meter reading is small compared to what has been the normal reading of the instrument, it is a pretty safe assumption that the defect is between the two segments to which the instrument is connected. If the defect is in one coil, the deflection of the meter can never be less than one-half normal, under which condition one coil would be completely short-circuited. It has already been shown that when the meter is connected to segments 16 and 17 it is connected to the terminals of coils 10 and 23 in series. Therefore, if when the coils are in good condition the meter reads one-half scale, then if one coil was completely short-circuited

method is desirable. Calling segment 16 number 1 and counting 13 to the right and also to the left, the count will end on segments 3 and 4 respectively. Doing this for segment 17 will end on segments 4 and 5. Since segment 16 is connected to both segments 3 and 4, which gave a low reading, and 17 does not, it is known that one terminal of the defective coil connects to segment 16 and that counting back 13 to the left from segment 16 locates segment 4 to which the other lead of the defective coil connects. It should be mentioned that when the low reading is obtained at segments 16 and 17, the segments should be marked with chalk, likewise segments 3 and 4. This will make it easy to refer to them when locating the defect. The foregoing discussion has been given to show that by a little study the one making the test can get a fair idea about where the defect lies before it is actually located by test.

Locating the Defective Part

In practice the next move after getting a low reading on segments 3 and 4 would be to connect the voltmeter from segment 4 to 16, or 3 to 16, since these are the pitch of the coil leads apart. If the meter is connected from segments 4 to 16, as indicated in dotted lines, then it will be connected directly to the leads of coil 16, which is the defective one. Now when a reading is taken from adjacent segments two coils are in series, and if the coils were in good condition it was assumed that the reading was about one-half scale deflection. Then, if the instrument is connected to one coil, it will not give over one-half of that for two coils, or in this case, one-quarter scale deflection. Since coil 16 is defective, then the reading will be lower than one-quarter deflection, and in this way by test the defective coil is located. After this has been done, the leads may be unsoldered from the segments so as to get at the defective coil. If, when the leads from segments 4 and 16 are unsoldered, they are marked it will be found, when the other leads are unsoldered, that the defective coil will have both its leads marked, where there will be two good coils each with one lead marked. This gives one way of identifying the faulty coil, when taking it out of the winding.

Procedure When Fault Is in the Commutator

If the fault had been in the commutator instead of in the coils, the readings obtained in the two locations in the commutator would not have been the same. If it is apparent that the defect is in the commutator, then the leads may be raised from the commutator as in Fig. 4. The coil leads may be left soldered together as in the figure and readings taken, as shown, from each pair, as from adjacent commutator segments. If the coils are in good condition, these readings should be the same as the normal obtained from the commutator. If a reading is below normal, it is an indication of a defective coil, as already explained. If there is a short-circuit between two segments, this can be located with a test lamp after the coils have been disconnected. After a little study and practice the tester will soon learn what the different deflections on the meter may mean and get at the seat of the trouble with little difficulty. Of course, there are, in a new winding, different combinations of faults that can occur to make the problem of locating the defects involved. However, if the winder has been careful in doing his work, the defects in the completed winding should be few and easily located.

The next article will discuss the methods of locating groups of short-circuited coils.

Government Specifications for Lubricating Oil

General Statement

This specification covers the grades of petroleum oil used by the United States Government and its agencies for the lubrication of air compressors and internal-combustion engines, except aircraft, motorcycle and Diesel engines; also for the lubrication of turbines and other machinery where a high-grade oil is required. This oil shall be satisfactory for use in circulating and forced feed systems.

Only refined petroleum oils without the admixture of fatty oils, resins, soaps or other compounds not derived from crude petroleum, will be considered.

Grades of Oil

These oils shall be supplied in five grades, known as extra-light, light, medium, heavy, and extra-heavy.

Flash and Fire Points—The flash and fire points of the five grades shall not be lower than the following:

Grade	Flash Point, Deg. F.	Fire Point, Deg. F.
Extra-light	315	355
Light	325	365
Medium	335	380
Heavy	345	390
Extra-heavy	355	400

Oil for use in air compressors where the air leaving any stage or cylinder has a temperature above 212 deg. F. shall have a flash point not lower than 400 deg. F.

Viscosity—The viscosity of the five grades at 100 deg. F. shall be within the following limits:

	Seconds
Extra-light	140-160
Light	175-210
Medium	275-310
Heavy	370-410
Extra-heavy	470-520

Color—The color of the extra-heavy grade shall not be darker than No. 6 National Petroleum Association standard, or its equivalent. The color of the other grades shall not be darker than No. 5 National Petroleum Association standard, or its equivalent.

Pour Test—The pour test shall not be above the following temperatures:

	Deg. F.
Extra-light	35
Light	35
Medium	40
Heavy	45
Extra-heavy	50

Acidity—Not more than 0.05 mg. of potassium hydroxide shall be required to neutralize 1 gram of the oil under examination.

Corrosion—A clean copper plate shall not be discolored when submerged in the oil for 24 hours at room temperature.

Emulsifying Properties—The oil shall separate in 10 minutes from an emulsion with: (1) Distilled water; (2) 1 per cent salt solution; (3) normal caustic solution. The demulsibility shall not be less than 300 by A.S.T.M. method.

This means that there shall be only a slight cuff between the water and the oil.

Carbon Residue—The carbon residue shall not exceed the following:

	Per Cent
Extra-light	0.10
Light	.20
Medium	.30
Heavy	.40
Extra-heavy	.60

All tests shall be made according to the methods of testing lubricants adopted by the Committee on Standardization of Petroleum Specifications.

An Efficiency Ratio for Surface Condensers

By PAUL A. BANCEL
Condenser Department, Ingersoll-Rand Company

IN the study of steam-engine and turbine performance it is customary to make use of the ratio of the useful work obtained from a pound of steam to that obtainable from a pound of steam expanding in a perfect engine from the same initial pressure and condition to the same exhaust pressure. In the study of surface condensers a similar ratio—the over-all heat-transmission coefficient of the condenser divided by that of a single tube tested under laboratory conditions—should make possible a clearer distinction between the effects of the various factors that determine every-day performance.

A COEFFICIENT of heat transfer is a convenient method of analyzing condenser performance, but it is subject to many different and varying influences. It is suggested that condenser performances be analyzed on the basis of "efficiency ratio" as well, this term being the ratio between the over-all coefficient of the condenser, which can be defined as the "condenser coefficient," and the coefficient under ideal conditions in a laboratory test of a single tube with all other conditions the same, which may be defined as the "physical coefficient." Then

$$\textit{Efficiency Ratio} = \frac{\textit{Condenser Coefficient}}{\textit{Physical Coefficient}}$$

This efficiency ratio is analogous in many respects to the Rankine Cycle efficiency ratio of a turbine. An example will serve to show how an efficiency ratio is obtained. The following data are abstracted from tests on a 30,000-kw. steam turbine, reported by H. B. Reynolds at the A. S. M. E. Chicago meeting in May, 1921:

Load, steam per hour, lb.	317,000
Inlet water temperature, deg. F.	76.5
Outlet water temperature, deg. F.	86.3
Vacuum, inches of mercury (30-in. barometer)	28.17
Gallons per minute	61,500
Approximate water velocity (not given by author), ft. per sec.	6
Coefficient of heat transmission, "condenser coefficient"	368

The physical coefficient (that is, the heat-transmission coefficient for a single tube under good conditions of steam velocity and air removal) for the same conditions of mean water temperature and water velocity, as determined in the work of George A. Orrok, is in the neighborhood of 900.[1] The efficiency ratio is, therefore, approximately 41 per cent (368÷900).

The efficiency ratio is convenient in studying the effects of air leakage, load and vacuum on condenser performance. As is well known, excess air leakage causes a fall in vacuum and a reduction in efficiency ratio. It is also well known that if the load on a condenser is reduced the vacuum goes up, while the coefficient tends to fall and at light loads falls to a low figure, only a few tubes being active.

Similarly, as the vacuum increases due to colder water at colder seasons of the year, the efficiency ratio falls off more and more. These changes in efficiency ratio are due principally to the changing air-removal conditions. The devaporization of the air and its removal are both increasingly difficult the higher the vacuum.

Fig. 1 shows the efficiency ratio plotted against vacuum for a large condenser of the usual proportions of approximately two square feet per kilowatt. These vacua were obtained with different loads and with two groups of injection-water temperatures. Fig. 2 shows a similar curve for another installation for fixed load and varying vacuum, due in this case to the change in water temperature only. The general nature of these characteristics is flat, with a rapid drop around 28½ in. to 29 inches.

While certain changes in relative efficiency under different conditions are always to be expected, the absolute efficiency may be high or low, depending on the condenser design. The efficiency characteristics of condensers may be compared to the efficiency curves of centrifugal pumps, which are of similar shapes with high or low average value, depending on the design. For example, reference to tests on centrifugal pumps of old design show efficiencies under normal operating conditions of about 45 per cent, with an efficiency curve varying with capacity as shown by *A*, Fig. 3. Nowadays, a high-grade centrifugal pump will show an efficiency characteristic of the same general shape (*B*, Fig. 3), but averaging much higher throughout the range.

It is evident from the foregoing that the "condenser coefficient" depends on the following:

1. The efficiency ratio, in turn dependent on (*a*) condenser design, (*b*) conditions of load, temperature, vacuum, air leakage, etc.

2. The physical coefficient for a single tube in a good current of steam, dependent principally on the metal of the tube, diameter of the tube, water velocity and mean temperature of the water. The efficiency ratio and the factors determining the performance of a single tube, are all within the control of the designer. Furthermore, the laws controlling the variations in efficiency have been studied for a wide range of conditions and are susceptible of analysis and application just as are the laws governing the physical coefficient for a single tube.

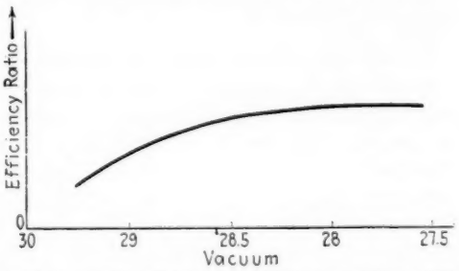


FIG. 1. RELATION BETWEEN VACUUM AND EFFICIENCY RATIO OF TYPICAL SURFACE CONDENSER

Curve drawn from readings for several different water temperatures and several loads at each water temperature.

In actual continued service a condenser frequently shows lower vacuum than that obtained with a new installation. Low vacuum and correspondingly low con-

[1] From Table 5 on page 1473, Vol. 32 (1910), *Transactions* of A.S.M.E., in an article by Mr. Orrok entitled "Transmission of Heat in Surface Condensation." This table gives the results of tests made to determine the effect on heat transfer of variations in mean temperature difference. The water velocity and mean temperature of the water were varied through a large range. The results are shown by curves on page 1002, Vol. 37 (1915) of the Transactions in an article on "High Vacuum Surface Condensers," by George H. Gibson and the author of the present article.

denser coefficient are due to reduction in either the efficiency ratio or the physical coefficient.

Reduction in Efficiency Ratio

Two things principally can happen to reduce the efficiency ratio of a condenser in commercial service below the efficiency normal to the apparatus, the load and the vacuum: First, air leakage may increase, and secondly, vacuum-pump capacity may fall off.

The avoidance of excessive air leakage is a matter of operating care and proper checking by instruments or air-bell tests to indicate when leakage is excessive. Reserve against excessive fall in vacuum under abnormal air leakage is provided by true counter-current air cooling, so that the lowest temperature and the maximum partial air pressure are obtained at the suction of the vacuum pump under the most adverse conditions. With counter-current air cooling, this reserve is increasingly valuable as the air-removal problem becomes more acute. This applies generally to all types of condensers, whether surface or jet, and may be expressed in another way by saying that if no leakage at all were experienced, counter-current construction would be unnecessary. As to falling off of vacuum-pump capacity, this can be determined by periodic tests and can be rectified only by repairs or replacements.

Reduction in Physical Coefficient

The second cause of reduction in the condenser coefficient under practical operating conditions is the falling off of the physical coefficient, which is dependent in turn on the degree of fouling of the tubes. This fouling is usually slime or scale. In some cases the vacuum in the summertime falls an inch or more in a week, so that even if the condenser is cleaned frequently, the operating vacuum averages a half-inch low with corresponding loss of turbine economy.

The degree of fouling that occurs between cleaning periods can be reduced by chemical treatment of the water and by proportioning the plant for high water velocities in the tubes. High water velocities reduce the stagnation and heating at the inner wall or skin of the tubes and retard fouling by either slime or scale. In fact, it is found in some cases that high velocity for short periods (as obtained by the use of extra large quantities of water) will clean out tubes that have been previously fouled.

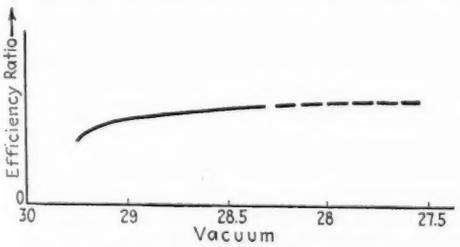


FIG. 2. RELATION BETWEEN VACUUM AND EFFICIENCY RATIO AS WATER TEMPERATURE CHANGES

Showing a curve drawn for a fixed load, but for a range of water temperatures from winter to summer.

When the vacuum falls due to fouling, the efficiency ratio increases according to the general characteristic shown in Figs. 1 and 2, just as it would if the vacuum fell due to the circulating water being warmer. This counteracts the fall in physical coefficient somewhat, particularly at the high vacuum in the winter. Unfortunately, the fouling is most severe in the summer, when the efficiency-ratio characteristic is almost flat. The counteracting influence of increased efficiency ratio is least at the time of the year when it is needed most. This applies to any design of condenser regardless of whether its average efficiency ratio is high or low.

Reserve against loss of vacuum by fouling must be provided, therefore, by correcting conditions on the inside of the tubes, as by the use of high velocities. How much water should be used and how much circulating pump power is desirable are questions to be settled in each plant. If clean drinking water were the circulating medium, the best balance between water velocity and the size of the condenser would lie at the point where the sum of the fixed charges against the condenser plus the operating cost of the circulating pump is a minimum. But under actual conditions in most plants the tubes foul and cause loss of operating vacuum, so that the best balance of fixed charges against the condenser and operating charges against the pump comes at a higher and higher water velocity. The best proportions are not susceptible of mathematical calculation, but must be determined by good judgment just as with many similar problems in power-house design.

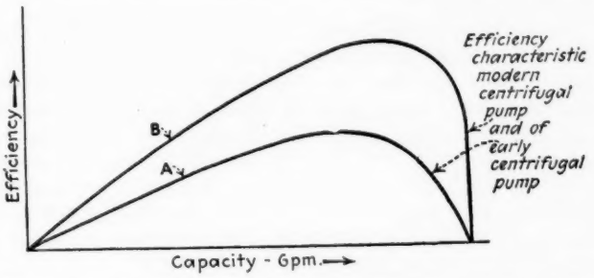


FIG. 3. RELATION BETWEEN EFFICIENCY AND CAPACITY FOR CENTRIFUGAL PUMPS OF MODERN AND EARLY TYPES

Schutte & Koerting Emergency Closing Valve for Large Steam Pipes

According to present-day practice in the installation of large turbine units, it is recognized that there ought to be a valve, in addition to the throttle valve, in the individual steam supply pipe of the turbine, right next to the connection of this pipe with the main steam header. One reason is that this extra valve may be closed to allow of repairing the throttle valve without interfering with the operation of other turbines supplied from the same header. Another, and perhaps more important, reason is that in case of turbine trouble it is sometimes impossible, or at least dangerous, to get near enough to the throttle valve to close it, and at such a time an extra valve next to the header makes it possible to shut off the steam supply to the unit that is giving trouble, without affecting the others.

The engineers of the Schutte & Koerting Co., Philadelphia, Pa., have designed for this use a valve that is intended to close practically instantaneously in case of accident. The closing is done by a tension spring which is released by a piston in the hydraulic trip cylinder, which is shown in the upper part of the illustration.

This cylinder is connected with the two pipes at the top in such a way that when the pressure drops in the relief pipe at the left, the pressure in the supply pipe at the right moves the piston over to the left, releasing the so-called latching-up lever. This lever turns on a sta-

tionary pivot just above the coil tension spring and is pivoted also to the sliding nut, which is threaded to receive the main operating spindle of the valve. It may be seen, therefore, that when the latching-up lever is released, the coil tension spring is allowed to close up, thus drawing out the sliding nut together with the spindle inside it, which in turn draws out the so-called bypass spindle and closes the main valve with the help of the steam pressure.

Since the valve is placed in the line in such a way that the steam pressure tends to keep it closed, a dashpot arrangement is necessary to prevent a violent shock upon closing. This dashpot consists of a cylinder in which slides a piston that is formed by the end of the valve spool. When the latter moves toward the closed position, it leaves a partial vacuum behind it, so that its motion is held back by the pressure in front of it. It is allowed to close gradually by small throttle screws, which relieve the partial vacuum by letting in steam from the main valve body. These screws can be adjusted to cause a quick or a slow closing of the valve.

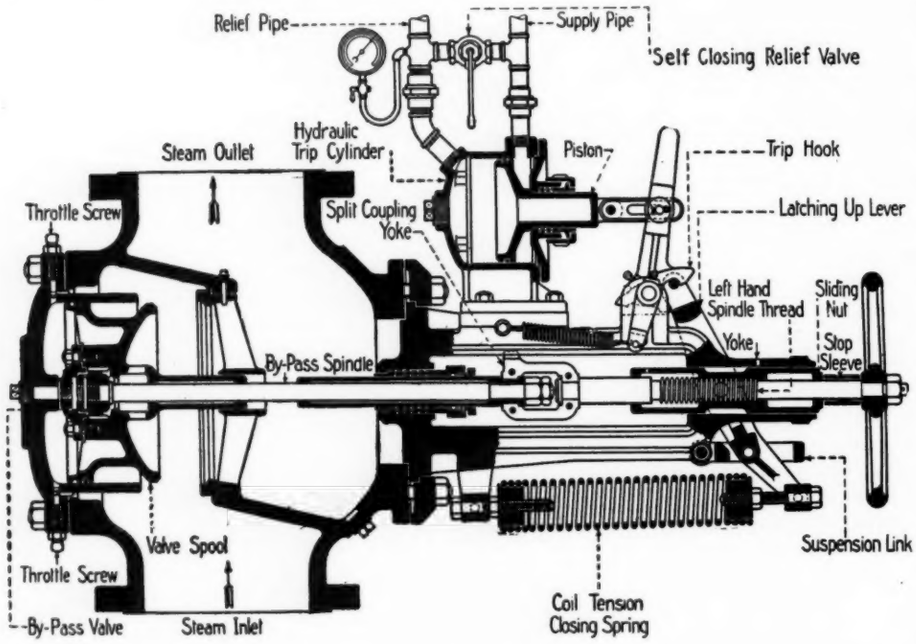
The valve must be opened by hand. In the closed position the top of the latching-up lever is over toward the right (instead of the left, as shown in the illustration), and so the sliding nut extends out of the yoke to the right instead of the left. Turning the handwheel to the right (the thread is left-hand) brings the nut and the latching-up lever to the open position, and if the hydraulic piston has also been returned to the open position, the trip hook engages the lever and holds it in place. Then, if the handwheel is turned to the left, since the nut must now remain stationary, the spindle can be screwed in so as to raise the valve spool from its seat.

Before opening the valve, the pressure on both sides is equalized by a bypass valve on the end of the so-called bypass spindle, which, it will be noticed, is connected with the threaded spindle in such a way that it does not turn. When the valve spool is drawn to its seat, the bypass valve is closed; and before the main valve is opened, the bypass spindle is pushed in by the threaded spindle, the end play is taken up, and the bypass valve is opened. There is then a passage for the steam past the throttle screws into the dashpot cylinder, through the bypass valve and into the outlet end of the main valve body, thus equalizing the pressure.

The hydraulic trip cylinder is filled with water on both sides of the piston. This water is ordinarily under 25 lb. pressure and is supplied either from the city main or from the discharge side of the boiler-feed pump. The pressure is maintained at all times in the right-hand end of the cylinder through the open supply pipe, but as soon as the other end of the cylinder, together with the piping connected with it, is filled, a self-closing relief valve between the supply and the relief pipe closes. Under such conditions, if water is let out of the relief pipe at any point, the constant pressure in the right-hand end of the hydraulic trip cylinder will force the piston over to the left, releasing the catch and closing the main valve.

The valves in the relief pipe are of four different types. One is the latch lever valve, which may be placed in any part of the station and operated by hand to close the main valve in case of any emergency. The other valves provide particularly against three emergencies; one is operated by steam pressure in the steam supply pipe to the turbine, another by the overspeed governor and a third by the pressure of the lubricating oil; thus the emergency valve will be closed by a break in the steam pipe between the valve and the turbine (a decrease in pressure in the steam pipe operates a diaghragm-controlled relief valve), by overspeeding of the turbine, by failure of the lubricating-oil supply or by operation of the hand-operated latch lever valves.

An electrical arrangement may be substituted for the hydraulic trip cylinder and the relief piping if desired. This consists of an electromagnet having an armature in the shape of a swinging weight, which, when the circuit through the magnet is broken, drops and trips the main valve shut. The same four methods of control are provided in this system as in the hydraulic system, the various hand-operated switches and automatic circuit breakers being connected in series with the electromagnet.



EMERGENCY CLOSING VALVE AS SECONDARY PROTECTION FOR LARGE TURBINE UNITS

It may be closed from a distance by hand, and is closed automatically in case of a broken steam pipe, overspeeding of the turbine, or failure of the lubricating oil supply. Escape of water from the relief pipe allows the hydraulic piston to move to the left, releasing the valve spindle, so that the valve spool is drawn to its seat by the combined action of the steam and the coil-tension closing spring.

Public Buildings as an Opportunity for the Operating Engineer

By CHARLES L. HUBBARD*

THE mechanical plants of such public buildings as schools, theaters, hotels, office buildings, etc., are an attractive field for the operating engineer. Before taking his first job in such a plant, the engineer should learn as much as possible about the operation of heating and ventilating equipment. The present article outlines in a simple and practical manner, the needed information along this line.

WHILE the plant devoted entirely or principally to the generation of power may have greater attractions for the average engineer, the opportunities offered in public buildings where heating and ventilation ordinarily take precedence, are not to be lost sight of. Buildings of this kind include schools in cities and large towns, public libraries, concert halls and theaters, city churches of the largest size and latest construction, public institutions, hotels and office buildings. It is proposed in the present article to deal principally with matters relating to the heating and ventilating side and to equipment not found in the average power plant.

There are numerous ways in which the position of engineer in a modern city school building, library or hospital should prove attractive, as compared with that in an industrial or power plant. The requirements for filling the post are not so exacting, the pay is usually good, and the hours of actual running, especially in school buildings, comparatively short.

The equipment coming under the charge of the engineer in a building of this kind may include boilers, steam engines and turbines of small size, pumps, dynamos, electric motors, air washers, ventilating fans, temperature-control apparatus and steam and hot-water heating systems of various kinds. A man who is at present employed in a power plant and wishes to fit himself for a position of this kind, will only have to post himself upon the special apparatus that relates to heating and ventilation and the general methods of operation to secure the best results. There are certain general principles with which the prospective engineer should be familiar, with regard to the equipment under his care and its operation, and it is the purpose of the present article to give as much of this information in condensed form as space will allow.

The heating and ventilating systems may be entirely separate or combined to a certain extent. In the first case (Fig. 1) the building is warmed by direct coils or radiators, and the fresh air supplied at room temperature (70 deg.) by means of a fan. Air is exhausted by separate vent flues, the flow being produced either by the air pressure in the room due to the supply fan, or by means of an exhaust fan located in the attic and connected with the vent flues.

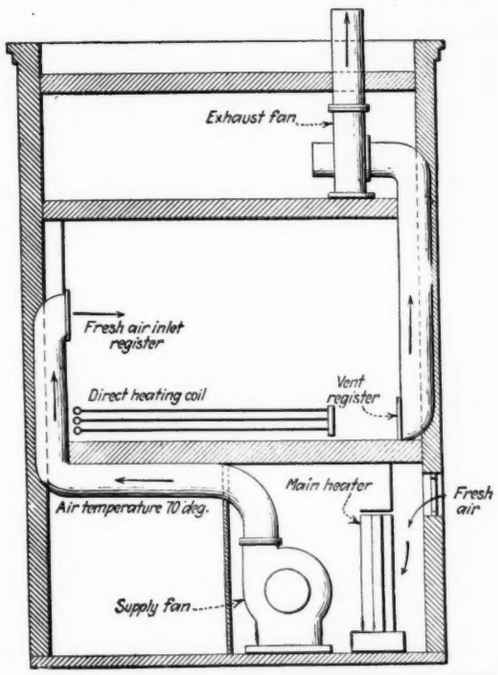


FIG. 1. DIRECT HEATING COILS WITH SEPARATE WARM-AIR VENTILATION

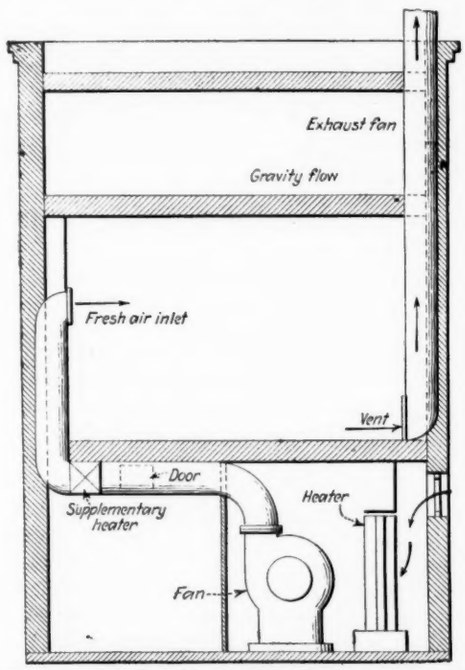


FIG. 2. INDIRECT HEATING AND VENTILATION COMBINED

*Consulting engineer, Boston, Mass.

In the combined arrangement (Fig. 2) part of the heating surface is in the supply airways between the fan and rooms, usually at the bases of the vertical flues leading to the latter. In Fig. 1 the two systems are entirely independent, and the rooms may be warmed equally well whether the fan is running or not. With the indirect or combined system special openings must be provided in the ducts to admit air below the heaters

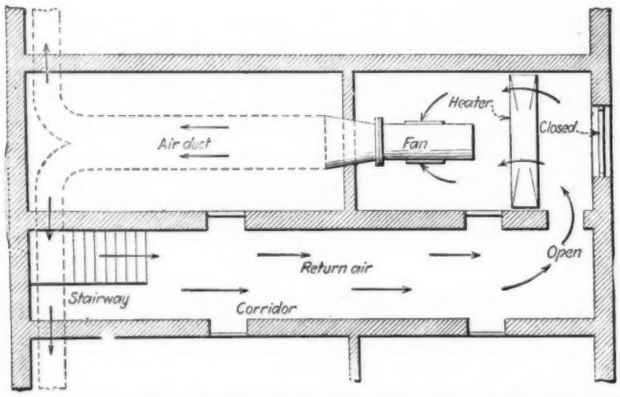


FIG. 3. IN HEATING UP BEFORE BUILDING IS OCCUPIED CLOSE COLD-AIR INLET AND OPEN DOORS TO CORRIDORS

in order to produce a gravity circulation when the fan is not running and so keep the building warm when ventilation is not required. Otherwise the circulation of air over the indirect heaters would be so sluggish that the rooms would not be sufficiently heated in cool weather. The main heater at the fan is usually designed to warm the full quantity of air supplied from zero to 70 or 75 degrees.

For quick warming in the morning, the outside inlet should be closed and the air drawn from inside the building until about ten minutes before school opens. In this way the same air is passed again and again through the heater and the temperature of the building quickly brought to normal. During this operation all classroom doors should be opened into the corridors, and the latter, together with the stairways, made to serve as return ducts to the fan and heater. This operation is shown diagrammatically in Fig. 3 and may be used temporarily on very cold days for maintaining the desired temperature in the rooms, should the direct or supplementary radiation prove insufficient.

Proper Handling of Fans

The centrifugal steel-plate fan, of the paddle-wheel or multi-vane type, is commonly used for this work, the latter being of later design and more compact for a given capacity. Motor-driven fans should be designed for running at normal motor speed, without throwing resistance into the circuit, and should be slowed down only on special occasions, when but a portion of the air supply is required (as during evening sessions in part of the rooms, or a lecture in the assembly hall).

When speeding up a fan to secure greater capacity it should be remembered that the power required increases much more rapidly than the capacity. If, for any reason, it is desired to reduce the air volume for a considerable period of time without changing the winding of the motor, it is better to block off a portion of the main air duct than to reduce the speed of fan by the use of the rheostat. Reducing the air volume in this way also reduces the power required, and so brings about the desired result without wasting electric power in the resistance coils of the motor. The main heater at the fan is proportioned for warming the maximum quantity of air in the coldest weather and is therefore too large for its work most of the time.

The temperature of the air delivered to the building may be regulated in two ways—either by dividing the heater into a number of valved sections and using as many of these as may be required for different outside temperatures, or by keeping steam on the entire heater and bypassing varying proportions of cool air around it and mixing with the hot air in the fan. The best results are obtained with a combination of these two methods, as shown in Fig. 4. With this arrangement approximate regulation for the day may be made by use of the valved sections, using a sufficient number to give slightly more heat than is required, accurate regulation being maintained by adjusting the bypass or mixing damper. This is easily controlled, acts quickly and may be set accurately for slight changes in temperature.

Control of Indirect Heater

In most buildings the valved sections of the heater are manipulated by hand and the bypass damper operated automatically by means of a thermostat placed in the warm-air duct beyond the fan. In either case a large and accurate thermometer should be connected with the main airway for indicating the temperature at

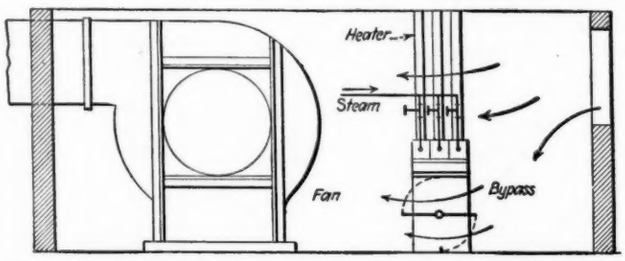


FIG. 4. METHOD OF OPERATING IN MODERATE WEATHER
In moderate weather put steam into several sections of the heater (enough to give a temperature somewhat above 70 deg. with the bypass closed). Then lower the temperature to exact point desired by adjusting the bypass damper.

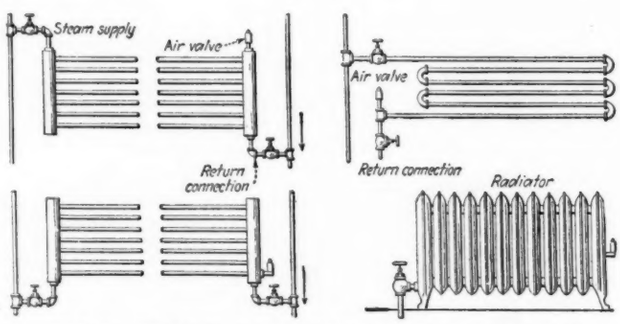


FIG. 5. PROPER LOCATION OF AIR VALVES FOR DIFFERENT STEAM AND RETURN CONNECTIONS

all times, and great care should be taken not to send air to the rooms at a temperature below 70 degrees.

If the fan is driven by a steam engine or turbine, as is sometimes the case, the exhaust should be condensed in certain sections of the main heater set apart for this purpose, using a sufficient number to care for all the exhaust, so that none will be wasted. Exhaust sections should be so valved that they may be supplied either

with live steam or exhaust steam from the fan engine as conditions may require.

Direct-heating equipment, where used, is generally in the form of coils or wall radiation in class and recitation rooms, and cast-iron sectional radiators in the smaller rooms. The principal care of this part of the equipment will relate to air venting and keeping the valve stems properly packed. If the air valves are correctly located, it will be simply a matter of adjustment.

Sometimes the air valves are not properly located, especially on circulation coils, and there will be trouble

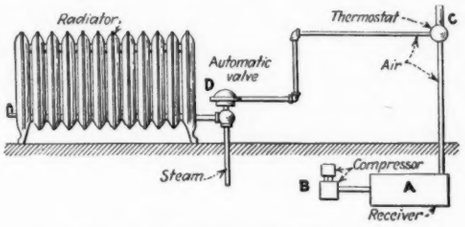


FIG. 6. THE THERMOSTAT CONTROLS THE RADIATOR VALVES BY MEANS OF COMPRESSED AIR

from "air-pocketing," in which case certain pipes or sections will remain cold. The proper locations of air valves for different steam and return connections are shown in Fig. 5. If any do not correspond with these and the coils give trouble in any way, the location of the air valve should be changed.

At the first complaint of lack of heat in any room, first see if the steam and return valves are open and then examine the air valves. Air-binding is the most frequent cause of non-heating in large buildings where direct radiation is used.

With the return-line vacuum system the air valve is combined with the return valve of the coil or radiator. In case this system is employed, the engineer should familiarize himself with the mechanism of the special valve used and look for trouble at this point if any room fails to heat properly.

When supplementary heaters in the flues are used instead of wall coils or radiators, all valves should be located outside the casing for easy inspection and adjustment. The care of heaters of this kind is much the same as for direct radiation.

Regulating the Temperature

Temperature regulation is one of the most important matters connected with operating a heating plant in a public building. Three-quarters of all the complaints of bad air and poor ventilation are due simply to overheating, while the remainder come from the odors given off from poorly cared for bodies and clothing. The latest theories of ventilation are based on a suitable temperature, proper humidity and air movement, rather than the chemical composition of the air. Of these three the effect of temperature is the most noticeable.

If the building is not equipped with automatic regulation, it will be practically impossible to obtain satisfactory results, as hand control must be left to teachers in schools, and attendents in other classes of buildings. If the building in question is not equipped with automatic regulation, the engineer should instruct those in charge of the different rooms in the best methods of regulating the temperature by frequent opening and closing of the radiator valves according to thermometer readings.

When supplementary heaters are used at the bases of the flues, as in Fig. 2, the best results are obtained by the use of mixing dampers rather than by shutting off and turning on the steam valves, as intermediate positions for the bypass damper may be found which will maintain a proper temperature for periods of considerable length.

The general principle of all systems of automatic control is practically the same and is shown diagrammatically in Fig. 6. An air pressure of about 15 lb. per sq.in. is automatically maintained in the receiver *A* by means of the compressor *B*, which is driven by electricity, steam or water pressure. From the receiver a pipe leads to a room thermostat *C*, which is a device so constructed that when the temperature reaches the maximum desired, the expansion of some substance acts to open a valve and pass the air pressure along to a pneumatic or diaphragm valve *D* at the radiator, and thus shut off the steam. When the temperature falls to the desired minimum, the reverse result is produced and steam is turned on. Most thermostats are designed to operate within a maximum range of two degrees and are arranged to actuate bypass dampers as well as valves.

Air Washers and Humidity Control

Air washers, in which the entering air passes through a spray of water, now form a part of the ventilating equipment of most large buildings, especially those exposed to city dust. These not only remove the soot and dust which the entering air may contain, but ordinarily add a certain amount of moisture, which is one of the requirements of good ventilation.

For the highest degree of comfort, air at a temperature of 70 deg. should have a relative humidity of

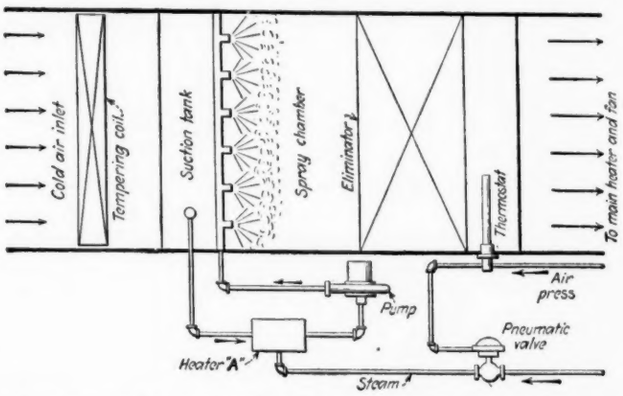


FIG. 7. ARRANGEMENT OF AIR WASHER TO MAINTAIN ANY DESIRED HUMIDITY

between 40 and 50 per cent; that is, it should be from 40 to 50 per cent saturated. If air at a given temperature and degree of saturation is heated without the addition of moisture, the relative humidity falls, so that while cold outside air may have a sufficient degree of humidity before heating, it becomes very dry before it reaches the rooms of a school building. The air washer may be made to give any amount of moisture desired to the entering air, up to the point of saturation, by varying the temperature of the spray water.

Washers designed especially for humidity control do this automatically, one form being illustrated in diagram in Fig. 7. Here the air leaving the washer is maintained at a constant temperature, depending upon the degree of

humidity required, by means of a duct thermostat located beyond the eliminator, as shown in the cut. The entering outside air is commonly raised to 30 or 40 deg. by means of the tempering coil, while the remainder of the work is done by the warm spray water through which it passes. The temperature of the air leaving the washer and passing to the main heater at the fan is fixed by the desired temperature and humidity of the air delivered to the building. For example, suppose the washer is located in a school building where the air is to be supplied at a temperature of 70 deg., with a relative humidity of 45 per cent. Air at this temperature and humidity contains 0.517 lb. of moisture per 1,000 cu.ft. This air, cooled to 46 deg. without the addition or removal of moisture, will become saturated. Hence, if saturated air at 46 deg. is passed to the main heater and then raised to 70 deg. without the addition of moisture, it will have a relative humidity of 45 per cent, as desired.

In the arrangement shown in Fig. 7, the air is raised, say to 30 or 35 deg. by the tempering coil, and the remainder of the heat required to raise it to 46 deg. is furnished by the warm spray water. This heat is provided by a special heater in the suction pipe to the circulating pump. The latter is supplied automatically with steam through a pneumatic valve operated by the thermostat beyond the eliminator. This thermostat is set for 46 deg., and if the air leaving the heater falls below this, more steam is admitted to heater *A* and the spray water raised to a higher temperature. The air passing through the warm spray is always saturated on leaving the washer under the conditions described.

An ordinary air washer may be equipped for hand control of humidity by placing a small steam coil in the pan or tank and regulating the temperature of the spray water by varying the quantity of steam admitted through a hand throttle valve, the condensation being discharged from the coil through an expansion trap. A dial indicator may be had which will show at all times the relative humidity of the air passing from the washer. With this arrangement the throttle valve in the steam pipe may be set to give a humidity between 40 and 50 per cent, as shown by the indicator, the valve being adjusted occasionally as conditions require.

The power equipment will vary with the type of building and local conditions and should receive the usual and necessary care, both for output and economy of operation. The same efforts should be made to secure a high furnace and boiler efficiency as in a power plant. Smoke restrictions are usually much more rigid, due to the locality.

The best textbooks for studying the special equipment found in combined power, heating and ventilating plants are illustrated trade catalogs. The man intending to take up this line of engineering should make a careful study of standard equipment in this way. After he has found his plant, he should provide himself with catalogs and blueprints of the particular makes of equipment found there, and obtain from the manufacturers all available information concerning them.

Influence of Viscosity on Operation of Oiling Systems

By W. F. OSBORNE
Supervisor Manufacturers' Service, Texas Company

IN THE previous articles we have seen that of all the various physical properties possessed by oils the principal one we have to consider in the lubrication of bearings is absolute viscosity. Together with the surface tension and the ability of the oil to wet or adhere to the metal, the absolute viscosity is the determining factor in the formation of the lubricating film.

Everything else being equal, we have found that the frictional resistance of a bearing in which a perfect film has been formed, is directly proportional to the absolute viscosity of the oil. We have seen further that the load-carrying capacity of a bearing is dependent upon the absolute viscosity of the oil. When conditions are such that a complete film is secured, a viscous oil will carry a greater load per square inch than a thin oil, without the film being broken. If there were no such property as viscosity, or the resistance of the oil to a change in shape or position, there would be no separation of the shaft from its bearing and metallic rubbing would result.

Effect of Viscosity

Although the effect of viscosity and the factors that influence the formation of a lubricating film have been pretty well worked out from a mathematical viewpoint, the difficulty of determining the actual magnitude of these influencing factors in various installations has made it necessary to gain our knowledge of these things chiefly by trying first one oil and then another. Every set of conditions has a very definite requirement as to the viscosity of the oil, in order that minimum friction may be attained. The difficulty lies in determining the conditions.

In a given installation the mechanical factors that have an influence on the viscosity are usually fixed beyond any adjustment, with the possible exception of the bearing clearance. Consequently, the usual method is to try oils of several viscosities until one is found that produces the lowest temperature, thus indicating a minimum frictional loss. Let us say that on a certain steam-turbine bearing the lowest temperature we are able to get with any kind of oil is 145 deg. F., and the oil that gives this temperature has an absolute viscosity of 12.4 centipoises at this temperature. If we have another turbine with identical bearing conditions, but owing to the use of superheated steam the bearings receive heat by conduction from the turbine casing equivalent to a fifteen-degree rise in temperature, in order to secure the same frictional loss as before we would have to use an oil with an absolute viscosity of 12.4 centipoises at 160 deg. F. If a higher-viscosity oil is used, the temperature will be higher due to increased

internal friction within the bearing. If a lower viscosity is used, the temperature will be increased because of wear due to lack of lubrication.

To meet the first condition we might purchase an oil having a Saybolt viscosity at 100 deg. F., of 180 seconds if its gravity were 28 deg. Bé., or 205 seconds if its gravity were 21 deg. Bé., both of these oils having exactly the same absolute viscosity at 145 deg. F. For the second condition we would purchase a 28 deg. Bé. gravity oil of 260 seconds viscosity or a 21 deg. Bé. oil of 300 Saybolt at 100 deg. F. Curves showing how this calculation is made were published at page 377, in *Power*, March 7, 1922.

In addition to having a very marked influence on the bearing temperatures, the absolute viscosity of the oil also affects the rate at which moisture and foreign matter will separate from the oil. A high-viscosity oil does not clean as readily or as rapidly as a lower-viscosity oil. This is one of the reasons why a high-viscosity oil is more likely to become emulsified than a low-viscosity oil. The separation of moisture and foreign matter from the oil in any circulatory system can be much improved by a reduction in viscosity.

This reduction in viscosity can be attained either by using a lower-viscosity oil initially or by reducing the viscosity of the oil through heating.

Increased Viscosity in Used Oil

Oils that have been in service in a circulatory system gradually increase in viscosity through a slow evaporation of the lighter fractions of the oil. Every oil is composed of many hydrocarbons, some of which have comparatively low boiling points. As the oil is agitated and mixed with air in its passage through the system, some of these hydrocarbons evaporate. Those lost are, of course, the hydrocarbons with the lowest boiling points, which also possess the lowest viscosities. This means that the oil remaining in the system increases in viscosity.

This increase in viscosity results in a gradual increase in bearing temperatures and a lowering of the rate of separation of moisture and other foreign material from the oil. In other words, a very important factor in the tendency of used oils to emulsify is the increased viscosity.

There is one exception to the general increase in viscosity of lubricating oils in service and that is when they are used in the crankcases of certain types of internal-combustion engines. Practically all such engines burning liquid fuel, will at times permit the passage of liquid fuel past the piston rings into the crankcase. With some types, such as the stationary kerosene engine, the automobile and tractor, this leakage of liquid fuel is very pronounced. The liquid fuel of course is very low in viscosity and the admixture of the low-viscosity fuel to the lubricating oil reduces the viscosity of the latter. This reduction of viscosity may be so great as to result in a serious loss of compression through improper piston seal or in actual wear of bearings through lack of sufficient viscosity to keep the shaft and bearings or the piston and cylinder from metallic rubbing.

Evidently an extremely important requirement of efficient lubrication is the selection of the right viscosity in the first place and the maintenance of the oil at that viscosity as long as possible. Whenever the viscosity changes materially from the correct point, there will be increased frictional heat, wear and rapid deterioration of the oil.

Fortunately, the safe range of viscosity is comparatively wide for most bearings, which permits the use of oils of several viscosities without permitting actual rubbing of the two metals together. This condition of affairs has the advantage that it has allowed engineers to believe that they were getting the best possible lubrication so long as there was no wear on the bearings. Even though the oil prevents wear, unless the viscosity is maintained within comparatively narrow limits, there will be unnecessary temperatures and loss of power through increased internal friction of the oil itself.

Influence of Viscosity on Circulatory System

Q. What is the influence of viscosity in the operation of a circulatory system, and how can I get the best results?

A. If the oil you select has the correct viscosity at your operating temperatures to meet the mechanical and operating conditions of your bearings, you will obtain the lowest possible friction losses, minimum power conconsumption and elimination of all wear caused by metallic rubbing of the moving parts. Any material departure of the viscosity, either up or down, from the correct point will result in a reduced efficiency of lubrication in some direction.

The life of the oil and the efficiency of lubrication will depend very largely upon the equipment available to maintain the oil at or near its original viscosity, together with freedom from foreign material. The viscosity should be carefully checked at frequent intervals, so that should there be any material increase or decrease, it can be corrected at once.

Q. How can I correct the viscosity of the oil in my circulatory system?

A. If the circulatory system is on a steam engine or a turbine, the viscosity will increase with service. It may be lowered by adding fresh oil at regular intervals or by introducing a small quantity of light-viscosity oil, the amount depending upon the increase in viscosity.

If the viscosity has been lowered through dilution by fuel, the fuel may be eliminated from the oil by heating or steaming the oil. The bad effects of dilution can sometimes be alleviated by the addition of a higher-viscosity oil.

The importance of high vacuum to a turbine may be appreciated by studying the amount of energy given up by steam expanding in a perfect turbine. Starting at 200 lb. absolute and 200 deg. superheat, if the power produced by a given weight of steam per hour expanded to 122 lb. absolute is taken as the unit, the power delivered for other final absolute pressures would be as follows: 69 lb., two units; 37 lb., three units; 18 lb., four units; 8 lb., five units; 3½ lb., six units; 1½ lb., seven units; ½ lb., eight units. Considering the two extremes, it is seen that as much power is taken from the last drop of one pound as from the first drop of 78 lb. The lower the pressure the more each pound of pressure drop counts with a turbine. That is the reason why turbine operators lay so much stress on the last inch of vacuum.

India has an engineering society of its own—the Institution of Engineers, which has local sections in Calcutta, Bombay and Madras. The membership totals 500 and includes engineers of all branches, since there are not enough in each branch to justify separate associations. The institute was formed over two years ago.

The Horsepower Constant of An Engine

THE horsepower developed in the engine cylinder may be quickly calculated by using a table of engine constants.

IN THE May 9 issue of *Power* the method of finding the horsepower developed in the engine cylinder was discussed. As then pointed out, the mean effective pressure is first found by measurement of the indicator diagrams for both cylinder ends. Knowing the area of the piston, the length of the stroke, the number of strokes made by the piston and the mean effective pressure, the horsepower is calculated by the formula

$$Hp = \frac{PlAN}{33{,}000}$$

where Hp = Indicated horsepower of the engine;
P = Average of the mean effective pressure of the two ends of the cylinder;
l = Length of stroke in feet;
A = Piston area in square inches;
N = Number of strokes per minute;
33,000 = The equivalent of a horsepower in foot-pounds.

This formula may be changed to the form

$$Hp = \frac{PAS}{33{,}000}$$

where A equals the piston area and S equals the piston speed.

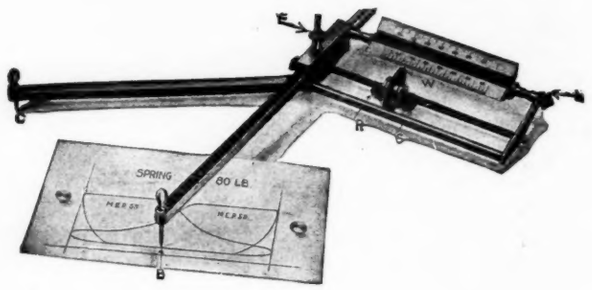
The piston speed S may be found by multiplying the piston stroke in feet by the number of strokes per minute or by twice the r.p.m. For example, if the engine has a 19-in. stroke and runs at 164 r.p.m., the piston speed is $\frac{19}{12} \times 225 \times 2 = 712.5$ ft. per min. Likewise the piston area A may be obtained by first squaring the diameter of the piston and multiplying the result by 0.7854, or $A = 0.7854d^2$.

The Engine Constant

In finding the piston area, if accuracy is desired, the cross-section of area of the piston rod must be deducted, for the pressure does not act over the area taken up by the rod. The same applies to the tail rod if one is used.

If these several steps are taken, a considerable amount of time and labor is involved. On the other hand taking the formula $Hp = \frac{PAS}{33{,}000}$, the piston area is fixed for any given engine as is also the piston speed. The formula is then divisible into two parts, one of which P (the m.e.p.) varies with the engine load, while the second part $\frac{AS}{33{,}000}$ is fixed for any given engine operating at a definite speed and is called the *engine constant*. With the engine constant known, the horsepower developed in the cylinder is found by multiplying P by this constant.

For the convenience of engineers the table on the opposite page has been made. This table of horsepower per pound of mean effective pressure covers most of the cylinder sizes in use. By entering the table at the desired cylinder size, say 20 in., and moving to the right until the column headed by the correct piston speed, say 800 ft., is reached, the horsepower constant is found at once, in this case 7.6160. This value, when multiplied by the average mean effective pressure for the two ends, gives the indicated horsepower developed in the cylinder. For example, a 20 x 24-in. engine running at 200 r.p.m. has a piston speed of $\frac{24}{12} \times 200 \times 2 = 800$ ft. The constant for a 20-in. cylinder at 800 ft. per min. is 7.6160, and if the m.e.p. is 50 lb. per sq.in. the indicated horsepower developed by the engine is $7.6160 \times 50 = 380.8$.



Deduction for Rod

Assuming that accuracy is desirable, it is necessary to deduct for the piston-rod area. If the rod be $2\frac{7}{16}$ in. in diameter, the horsepower that would be developed by the m.e.p. acting over this area must be deducted from the i.h.p. first calculated. Entering the table at $2\frac{7}{16}$, the constant for 800 ft. is found to be 0.1131. But this is correct only if the rod existed in both ends of the cylinder. It is necessary, then, to take only one-half of this amount, or 0.0566 if no tail rod is used. Multiplying this by 50 (the m.e.p.), the i.h.p. correction is found to be 2.83. The true indicated horsepower of the engine is 380.8 — 2.83 = 377.97.

The best method is to deduct the constant for the rod from the cylinder constant before multiplying by the m.e.p., or in this case 7.616 — 0.0566 = 7.5594, and the indicated horsepower is, as before, $7.5594 \times 50 = 377.97$.

If a tail rod is used equal to the piston rod in area, then the rod constant for both ends is 0.1131. The i.hp. is then 50 (7.616 — 0.1131) = 375.15.

Frequently, the piston speed will not correspond to the speeds shown in the table. For example, a 20 x 24 engine may run at 175 r.p.m. going at a piston speed of $\frac{24}{12} \times 180 \times 2 = 720$ ft. per min. This may be separated into two values, 700 and 20, or 700 + 20. The constant at 700 ft. per min. of a 20-in. cylinder is 6.6640, and the constant for 200 ft. is 1.9040, which becomes $\frac{1.9040}{10} = 0.1904$ for 20 ft. per min. The constants may now be set down as follows:

Constant for 700 ft.	6.6640
Constant for 20 ft.	0.1904
Constant for 720 ft.	6.8544

The same result may be obtained by taking the constant for 100 ft., or 0.952, and multiplying it by 7.2 to give a constant of $7.2 \times 952 = 6.8544$.

Horsepower per Pound of Mean Effective Pressure

(Area × piston speed) ÷ 33,000 = engine constant

Diameter of Cylinder or Rod, Inches	Piston Speed in Feet Per Minute 100	200	300	400	500	600	700	800	900
¼	0.00134	0.0027	0.0040	0.0054	0.0067	0.0080	0.0094	0.0107	0.0120
5/16	0.00157	0.0031	0.0047	0.0063	0.0079	0.0094	0.0110	0.0126	0.0141
⅜	0.00182	0.0036	0.0055	0.0073	0.0091	0.0109	0.0128	0.0146	0.0164
7/16	0.00209	0.0042	0.0063	0.0084	0.0105	0.0126	0.0146	0.0167	0.0188
1	0.00238	0.0048	0.0071	0.0095	0.0119	0.0143	0.0167	0.0190	0.0214
1 1/16	0.00269	0.0054	0.0081	0.0107	0.0134	0.0161	0.0188	0.0215	0.0242
1 1/8	0.00288	0.0058	0.0086	0.0115	0.0144	0.0173	0.0202	0.0230	0.0259
1 1/4	0.00301	0.0060	0.0090	0.0120	0.0151	0.0181	0.0211	0.0241	0.0271
1 5/16	0.00336	0.0067	0.0101	0.0134	0.0168	0.0201	0.0235	0.0268	0.0302
1 3/8	0.00343	0.0069	0.0103	0.0137	0.0171	0.0206	0.0240	0.0274	0.0308
1 7/16	0.00372	0.0074	0.0112	0.0149	0.0186	0.0223	0.0260	0.0297	0.0335
1 1/2	0.00402	0.0080	0.0121	0.0161	0.0201	0.0241	0.0282	0.0322	0.0362
1 9/16	0.00410	0.0082	0.0123	0.0164	0.0205	0.0246	0.0287	0.0328	0.0369
1 5/8	0.00450	0.0090	0.0135	0.0180	0.0225	0.0270	0.0315	0.0360	0.0405
1 11/16	0.00466	0.0093	0.0140	0.0187	0.0233	0.0280	0.0327	0.0373	0.0420
1 3/4	0.00492	0.0098	0.0148	0.0197	0.0246	0.0295	0.0344	0.0393	0.0443
1 13/16	0.00535	0.0107	0.0161	0.0214	0.0268	0.0321	0.0375	0.0428	0.0482
1 7/8	0.00581	0.0116	0.0174	0.0232	0.0291	0.0349	0.0407	0.0465	0.0523
1 15/16	0.00609	0.0122	0.0183	0.0244	0.0305	0.0366	0.0426	0.0487	0.0548
1	0.00628	0.0126	0.0189	0.0251	0.0314	0.0377	0.0440	0.0503	0.0566
2 1/16	0.00678	0.0136	0.0203	0.0271	0.0339	0.0407	0.0474	0.0542	0.0610
2 1/8	0.00688	0.0138	0.0206	0.0275	0.0344	0.0413	0.0481	0.0550	0.0619
2 3/16	0.00729	0.0146	0.0219	0.0292	0.0364	0.0437	0.0510	0.0583	0.0656
2 1/4	0.00771	0.0154	0.0231	0.0308	0.0386	0.0463	0.0540	0.0617	0.0694
2 5/16	0.00782	0.0156	0.0235	0.0313	0.0391	0.0469	0.0547	0.0625	0.0704
2 3/8	0.00837	0.0167	0.0251	0.0335	0.0418	0.0502	0.0586	0.0669	0.0753
2 7/16	0.00859	0.0172	0.0258	0.0344	0.0430	0.0516	0.0601	0.0687	0.0773
2 1/2	0.00893	0.0179	0.0268	0.0357	0.0447	0.0536	0.0625	0.0715	0.0804
2	0.00952	0.0190	0.0286	0.0381	0.0476	0.0571	0.0666	0.0762	0.0857
2 1/16	0.01012	0.0202	0.0304	0.0405	0.0506	0.0607	0.0709	0.0810	0.0911
2 1/8	0.01050	0.0210	0.0315	0.0420	0.0525	0.0630	0.0735	0.0840	0.0945
2 3/16	0.01075	0.0215	0.0322	0.0430	0.0537	0.0645	0.0752	0.0860	0.0967
2 1/4	0.01139	0.0228	0.0342	0.0456	0.0569	0.0683	0.0797	0.0911	0.1025
2 5/16	0.01152	0.0230	0.0346	0.0461	0.0576	0.0691	0.0806	0.0922	0.1037
2 3/8	0.01205	0.0241	0.0361	0.0482	0.0602	0.0723	0.0843	0.0964	0.1084
2 7/16	0.01259	0.0252	0.0378	0.0504	0.0630	0.0755	0.0881	0.1007	0.1133
2 1/2	0.01273	0.0255	0.0382	0.0509	0.0636	0.0764	0.0891	0.1018	0.1145
2 9/16	0.01342	0.0268	0.0403	0.0537	0.0671	0.0805	0.0940	0.1074	0.1208
2 5/8	0.01371	0.0274	0.0411	0.0548	0.0685	0.0823	0.0960	0.1097	0.1234
2 11/16	0.01414	0.0283	0.0424	0.0566	0.0707	0.0848	0.0990	0.1131	0.1273
2 3/4	0.01487	0.0297	0.0446	0.0595	0.0744	0.0892	0.1041	0.1190	0.1339
2 13/16	0.01563	0.0313	0.0469	0.0625	0.0781	0.0938	0.1094	0.1250	0.1407
2 7/8	0.01609	0.0322	0.0483	0.0644	0.0804	0.0965	0.1126	0.1287	0.1448
2 15/16	0.01640	0.0328	0.0492	0.0656	0.0820	0.0984	0.1148	0.1312	0.1476
2 1/2	0.01719	0.0344	0.0516	0.0688	0.0859	0.1031	0.1203	0.1375	0.1547
2 1/16	0.01735	0.0347	0.0521	0.0694	0.0868	0.1041	0.1215	0.1388	0.1562
2 1/8	0.01800	0.0360	0.0540	0.0720	0.0900	0.1080	0.1260	0.1440	0.1620
2 3/16	0.01866	0.0373	0.0560	0.0746	0.0933	0.1120	0.1306	0.1493	0.1679
2 1/4	0.01883	0.0377	0.0565	0.0753	0.0941	0.1130	0.1318	0.1506	0.1694
2 5/16	0.01967	0.0393	0.0590	0.0787	0.0984	0.1180	0.1377	0.1574	0.1770
2 3/8	0.02002	0.0400	0.0600	0.0801	0.1001	0.1201	0.1401	0.1601	0.1801
2 7/16	0.02054	0.0411	0.0616	0.0821	0.1027	0.1232	0.1438	0.1643	0.1848
2 1/2	0.02142	0.0428	0.0643	0.0857	0.1071	0.1285	0.1499	0.1714	0.1928
2 9/16	0.02287	0.0457	0.0686	0.0915	0.1144	0.1372	0.1601	0.1830	0.2058
2 5/8	0.02324	0.0465	0.0697	0.0930	0.1162	0.1395	0.1627	0.1859	0.2092
2 11/16	0.02437	0.0487	0.0731	0.0975	0.1219	0.1462	0.1706	0.1950	0.2193
2 3/4	0.02514	0.0503	0.0754	0.1006	0.1257	0.1508	0.1760	0.2011	0.2262
2 13/16	0.02599	0.0518	0.0778	0.1037	0.1296	0.1555	0.1814	0.2073	0.2333
2 7/8	0.02711	0.0542	0.0813	0.1084	0.1355	0.1627	0.1898	0.2169	0.2440
2 15/16	0.02751	0.0550	0.0825	0.1101	0.1376	0.1651	0.1926	0.2201	0.2476
3	0.02915	0.0583	0.0875	0.1166	0.1458	0.1749	0.2041	0.2332	0.2624
3 1/16	0.02751	0.0550	0.0825	0.1101	0.1376	0.1651	0.1926	0.2201	0.2476
3 1/8	0.03084	0.0617	0.0925	0.1234	0.1542	0.1851	0.2159	0.2468	0.2776
3 3/16	0.03127	0.0625	0.0938	0.1251	0.1564	0.1876	0.2189	0.2502	0.2815
3 1/4	0.03258	0.0652	0.0977	0.1303	0.1629	0.1955	0.2281	0.2607	0.2932
3 5/16	0.03347	0.0669	0.1004	0.1339	0.1673	0.2008	0.2343	0.2677	0.3012
3 3/8	0.03437	0.0687	0.1031	0.1375	0.1718	0.2062	0.2406	0.2749	0.3093
3 7/16	0.03574	0.0715	0.1072	0.1429	0.1787	0.2144	0.2502	0.2859	0.3216
3 1/2	0.03620	0.0724	0.1086	0.1448	0.1810	0.2172	0.2534	0.2896	0.3258
4	0.03808	0.0762	0.1142	0.1523	0.1904	0.2285	0.2666	0.3046	0.3427
4 1/16	0.04001	0.0800	0.1200	0.1600	0.2000	0.2400	0.2801	0.3201	0.3601
4 1/8	0.04050	0.0810	0.1215	0.1620	0.2025	0.2430	0.2835	0.3240	0.3645
4 3/16	0.04198	0.0840	0.1259	0.1679	0.2099	0.2519	0.2939	0.3359	0.3778
4 1/4	0.04299	0.0860	0.1290	0.1720	0.2149	0.2579	0.3009	0.3439	0.3869
4 5/16	0.04401	0.0880	0.1320	0.1760	0.2200	0.2640	0.3080	0.3520	0.3961
4 3/8	0.04555	0.0911	0.1367	0.1822	0.2278	0.2733	0.3189	0.3644	0.4100
4 7/16	0.04608	0.0922	0.1382	0.1843	0.2304	0.2765	0.3225	0.3686	0.4147
4 1/2	0.04819	0.0964	0.1446	0.1928	0.2410	0.2892	0.3374	0.3856	0.4338
4 9/16	0.05036	0.1007	0.1511	0.2014	0.2518	0.3022	0.3525	0.4029	0.4532
4 5/8	0.05091	0.1018	0.1527	0.2036	0.2545	0.3055	0.3564	0.4073	0.4582
4 11/16	0.05257	0.1051	0.1577	0.2103	0.2629	0.3154	0.3680	0.4206	0.4732
4 3/4	0.05370	0.1074	0.1611	0.2148	0.2685	0.3222	0.3759	0.4296	0.4833
4 13/16	0.05484	0.1097	0.1645	0.2193	0.2742	0.3290	0.3838	0.4387	0.4935
4 7/8	0.05656	0.1131	0.1697	0.2262	0.2828	0.3394	0.3959	0.4525	0.5091
4 15/16	0.05714	0.1143	0.1714	0.2286	0.2857	0.3429	0.4000	0.4571	0.5143
5	0.05950	0.1190	0.1785	0.2380	0.2975	0.3570	0.4165	0.4760	0.5355
5 1/16	0.06251	0.1250	0.1875	0.2500	0.3126	0.3751	0.4376	0.5001	0.5626
5 1/8	0.06560	0.1312	0.1968	0.2624	0.3280	0.3936	0.4592	0.5248	0.5904
5 3/16	0.06876	0.1375	0.2063	0.2750	0.3438	0.4126	0.4813	0.5501	0.6188
5 1/4	0.07199	0.1440	0.2160	0.2880	0.3600	0.4320	0.5040	0.5760	0.6480
5 5/16	0.07530	0.1506	0.2259	0.3012	0.3765	0.4518	0.5271	0.6024	0.6777
5 3/8	0.07869	0.1574	0.2361	0.3148	0.3934	0.4721	0.5508	0.6295	0.7082
5 7/16	0.08215	0.1643	0.2464	0.3286	0.4107	0.4929	0.5750	0.6572	0.7393
6	0.08568	0.1714	0.2570	0.3427	0.4284	0.5141	0.5998	0.6854	0.7711
6 1/16	0.09297	0.1859	0.2789	0.3719	0.4648	0.5578	0.6508	0.7437	0.8367
6 1/8	0.10055	0.2011	0.3017	0.4022	0.5028	0.6033	0.7039	0.8044	0.9050
6 3/16	0.10844	0.2169	0.3253	0.4338	0.5422	0.6506	0.7591	0.8675	0.9759
6 1/4	0.11662	0.2332	0.3499	0.4665	0.5831	0.6997	0.8163	0.9330	1.0496
6 5/16	0.12510	0.2502	0.3753	0.5004	0.6255	0.7506	0.8757	1.0008	1.1259
6 3/8	0.13387	0.2677	0.4016	0.5355	0.6694	0.8032	0.9371	1.0710	1.2049
6 7/16	0.14295	0.2859	0.4288	0.5718	0.7147	0.8577	1.0006	1.1436	1.2865
6 1/2	0.15232	0.3046	0.4570	0.6093	0.7616	0.9139	1.0662	1.2186	1.3709
6 9/16	0.16199	0.3240	0.4860	0.6480	0.8099	0.9719	1.1339	1.2959	1.4579
6 5/8	0.17195	0.3439	0.5159	0.6878	0.8598	1.0317	1.2037	1.3756	1.5476
6 11/16	0.18222	0.3644	0.5467	0.7289	0.9111	1.0933	1.2755	1.4577	1.6400

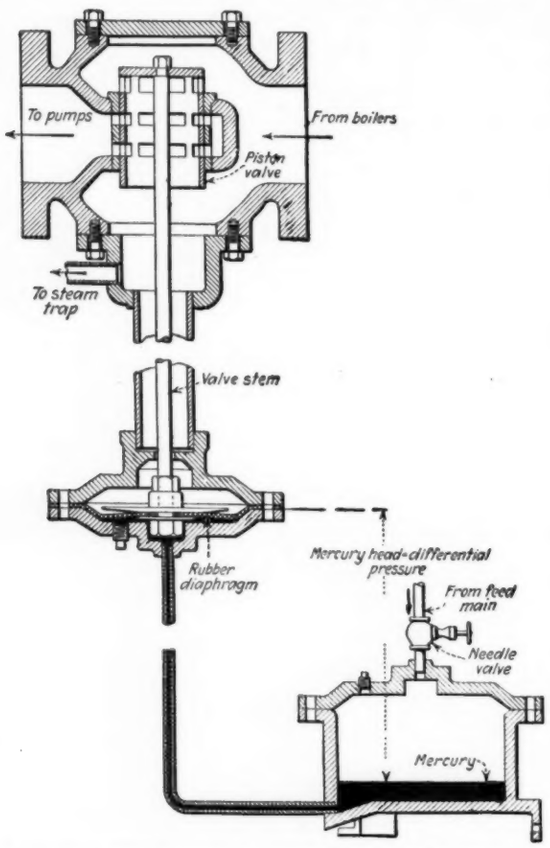
Diameter of Cylinder or Rod, Inches	Piston Speed in Feet Per Minute 100	200	300	400	500	600	700	800	900
9	0.19278	0.3856	0.5783	0.7711	0.9639	1.1567	1.3495	1.5422	1.7350
9 1/16	0.20364	0.4073	0.6109	0.8146	1.0182	1.2218	1.4255	1.6291	1.8327
9 1/8	0.21479	0.4296	0.6444	0.8592	1.0740	1.2888	1.5036	1.7184	1.9332
9 3/16	0.22625	0.4525	0.6787	0.9050	1.1312	1.3575	1.5837	1.8100	2.0362
10	0.23800	0.4760	0.7140	0.9520	1.1900	1.4280	1.6660	1.9040	2.1420
10 1/16	0.25005	0.5001	0.7501	1.0002	1.2502	1.5003	1.7503	2.0004	2.2504
10 1/8	0.26239	0.5248	0.7872	1.0496	1.3120	1.5744	1.8368	2.0992	2.3615
10 3/16	0.27504	0.5501	0.8251	1.1002	1.3752	1.6502	1.9253	2.2003	2.4753
10 1/4	0.28798	0.5760	0.8639	1.1519	1.4399	1.7279	2.0159	2.3038	2.5918
10 5/16	0.30122	0.6024	0.9037	1.2049	1.5061	1.8073	2.1085	2.4097	2.7110
10 3/8	0.31475	0.6295	0.9443	1.2590	1.5738	1.8885	2.2033	2.5180	2.8328
10 7/16	0.32859	0.6572	0.9858	1.3144	1.6429	1.9715	2.3001	2.6287	2.9573
10 1/2	0.34272	0.6854	1.0282	1.3709	1.7136	2.0563	2.3990	2.7418	3.0845
10 9/16	0.37187	0.7437	1.1156	1.4875	1.8594	2.2312	2.6031	2.9750	3.3469
10 5/8	0.40222	0.8044	1.2067	1.6089	2.0111	2.4133	2.8155	3.2178	3.6200
10 11/16	0.43375	0.8675	1.3013	1.7350	2.1688	2.6025	3.0363	3.4700	3.9038
10 3/4	0.46648	0.9330	1.3994	1.8659	2.3324	2.7989	3.2654	3.7318	4.1983
10 13/16	0.50039	1.0008	1.5012	2.0016	2.5020	3.0024	3.5028	4.0032	4.5035
10 7/8	0.53550	1.0710	1.6065	2.1420	2.6775	3.2130	3.7485	4.2840	4.8195
10 15/16	0.60927	1.2186	1.8278	2.4371	3.0464	3.6557	4.2649	4.8742	5.4835
11	0.68782	1.3756	2.0635	2.7513	3.4391	4.1269	4.8147	5.5025	6.1904
11 1/16	0.77112	1.5422	2.3134	3.0845	3.8556	4.6267	5.3978	6.1689	6.9401
11 1/8	0.85918	1.7184	2.5775	3.4367	4.2959	5.1551	6.0142	6.8734	7.7326
11 3/16	0.95200	1.9040	2.8560	3.8080	4.7600	5.7120	6.6640	7.6160	8.5680
11 1/4	1.04958	2.0992	3.1487	4.1983	5.2479	6.2975	7.3470	8.3966	9.4462
11 5/16	1.15192	2.3038	3.4558	4.6077	5.7596	6.9115	8.0634	9.2153	10.3671
11 3/8	1.25902	2.5180	3.7771	5.0361	6.2951	7.5541	8.8131	10.0721	11.3312
11 7/16	1.37088	2.7418	4.1126	5.4835	6.8544	8.2253	9.5961	10.9670	12.3379
11 1/2	1.48750	2.9750	4.4625	5.9500	7.4375	8.9250	10.4125	11.9000	13.3875
11 9/16	1.60888	3.2178	4.8266	6.4355	8.0444	9.6533	11.2621	12.8710	14.4799
11 5/8	1.73502	3.4700	5.2050	6.9401	8.6751	10.4101	12.1451	13.8801	15.6151
11 11/16	1.86592	3.7318	5.5977	7.4637	9.3296	11.1955	13.0614	14.9273	16.7932
11 3/4	2.00158	4.0032	6.0047	8.0063	10.0079	12.0095	14.0110	16.0126	18.0142
11 13/16	2.14199	4.2840	6.4260	8.5680	10.7100	12.8520	14.9940	17.1360	19.2780
11 7/8	2.28717	4.5743	6.8615	9.1487	11.4359	13.7230	16.0102	18.2974	20.5846
11 15/16	2.43711	4.8742	7.3113	9.7485	12.1856	14.6227	17.0598	19.4969	21.9340
12	2.59181	5.1836	7.7754	10.3673	12.9591	15.5509	18.1427	20.7345	23.3263
12 1/16	2.75127	5.5025	8.2538	11.0051	13.7564	16.5076	19.2589	22.0102	24.7615
12 1/8	2.91549	5.8310	8.7465	11.6620	14.5775	17.4930	20.4085	23.3239	26.2394
12 3/16	3.08447	6.1689	9.2534	12.3379	15.4224	18.5068	21.5913	24.6758	27.7603
12 1/4	3.25821	6.5164	9.7746	13.0328	16.2911	19.5493	22.8075	26.0657	29.3239
12 5/16	3.43671	6.8734	10.3101	13.7468	17.1836	20.6203	24.0570	27.4937	30.9304
12 3/8	3.61997	7.2399	10.8599	14.4799	18.0999	21.7198	25.3398	28.9598	32.5797
12 7/16	3.80799	7.6160	11.4240	15.2320	19.0400	22.8479	26.6559	30.4639	34.2719
12 1/2	4.00077	8.0015	12.0023	16.0031	20.0039	24.0046	28.0054	32.0062	36.0069
12 9/16	4.19831	8.3966	12.5949	16.7932	20.9916	25.1899	29.3882	33.5865	37.7848
12 5/8	4.40062	8.8012	13.2018	17.6024	22.0030	26.4037	30.8043	35.2049	39.6055
12 11/16	4.60767	9.2153	13.8230	18.4307	23.0383	27.6460	32.2537	36.8614	41.4690
12 3/4	4.81949	9.6390	14.4585	19.2780	24.0974	28.9169	33.7364	38.5559	43.3754
12 13/16	5.03607	10.0721	15.1082	20.1443	25.1803	30.2164	35.2525	40.2885	45.3246
12 7/8	5.25741	10.5148	15.7722	21.0296	26.2870	31.5444	36.8019	42.0593	47.3167
12 15/16	5.48351	10.9670	16.4505	21.9340	27.4175	32.9010	38.3845	43.8681	49.3516
13	5.71437	11.4287	17.1431	22.8575	28.5718	34.2862	40.0006	45.7149	51.4293
13 1/16	5.95000	11.9000	17.8500	23.8000	29.7499	35.6999	41.6499	47.5999	53.5500
13 1/8	6.19037	12.3807	18.5711	24.7615	30.9518	37.1422	43.3326	49.5229	55.7133
13 3/16	6.43550	12.8710	19.3065	25.7420	32.1775	38.6130	45.0485	51.4840	57.9195
13 1/4	6.68540	13.3708	20.0562	26.7416	33.4270	40.1124	46.7978	53.4832	60.1686
13 5/16	6.94006	13.8801	20.8202	27.7603	34.7003	41.6404	48.5804	55.5205	62.4606
13 3/8	7.19948	14.3990	21.5984	28.7979	35.9974	43.1969	50.3964	57.5959	64.7953
13 7/16	7.46366	14.9273	22.3910	29.8546	37.3183	44.7820	52.2456	59.7093	67.1730
13 1/2	7.73260	15.4652	23.1978	30.9304	38.6630	46.3956	54.1282	61.8608	69.5934
13 9/16	8.00630	16.0126	24.0189	32.0252	40.0315	48.0378	56.0441	64.0504	72.0567
13 5/8	8.28476	16.5695	24.8543	33.1390	41.4238	49.7086	57.9933	66.2781	74.5628
13 11/16	8.56798	17.1360	25.7039	34.2719	42.8399	51.4079	59.9759	68.5438	77.1118
13 3/4	8.85596	17.7119	26.5679	35.4238	44.2798	53.1358	61.9917	70.8477	79.7036
13 13/16	9.14870	18.2974	27.4461	36.5948	45.7435	54.8922	64.0409	73.1896	82.3383
13 7/8	9.44620	18.8924	28.3386	37.7848	47.2310	56.6772	66.1234	75.5696	85.0158
13 15/16	9.74846	19.4969	29.2454	38.9938	48.7423	58.4907	68.2392	77.9877	87.7361
14	10.05548	20.1110	30.1664	40.2219	50.2774	60.3329	70.3883	80.4438	90.4993
14 1/16	10.36726	20.7345	31.1018	41.4690	51.8363	62.2035	72.5708	82.9380	93.3053
14 1/8	10.68379	21.3676	32.0514	42.7352	53.4190	64.1028	74.7866	85.4704	96.1542
14 3/16	11.00509	22.0102	33.0153	44.0204	55.0255	66.0306	77.0357	88.0408	99.0458
14 1/4	11.33115	22.6623	33.9935	45.3246	56.6558	67.9869	79.3181	90.6492	101.9804
14 5/16	11.66197	23.3239	34.9859	46.6479	58.3099	69.9718	81.6338	93.2958	104.9578
14 3/8	11.99755	23.9951	35.9927	47.9902	59.9878	71.9853	83.9829	95.9804	107.9780
14 7/16	12.33789	24.6758	37.0137	49.3516	61.6895	74.0273	86.3652	98.7031	111.0410
14 1/2	12.68299	25.3660	38.0490	50.7320	63.4150	76.0979	88.7809	101.4639	114.1469
14 9/16	13.03285	26.0657	39.0985	52.1314	65.1642	78.1971	91.2299	104.2628	117.2956
14 5/8	13.38747	26.7749	40.1624	53.5499	66.9373	80.3248	93.7123	107.0998	120.4872
14 11/16	13.74685	27.4937	41.2405	54.9874	68.7342	82.4811	96.2279	109.9748	123.7216
14 3/4	14.11099	28.2220	42.3330	56.4439	70.5549	84.6659	98.7769	112.8879	126.9989
14 13/16	14.47989	28.9598	43.4397	57.9195	72.3994	86.8793	101.3592	115.8391	130.3190
14 7/8	14.85355	29.7071	44.5606	59.4142	74.2677	89.1213	103.9748	118.8284	133.6819
14 15/16	15.23196	30.4639	45.6959	60.9279	76.1598	91.3918	106.6237	121.8557	137.0877
15	15.61514	31.2303	46.8454	62.4606	78.0757	93.6909	109.3060	124.9211	140.5363
15 1/16	16.00308	32.0062	48.0092	64.0123	80.0154	96.0185	112.0216	128.0247	144.0277
15 1/8	16.39578	32.7916	49.1873	65.5831	81.9789	98.3747	114.7705	131.1662	147.5620
15 3/16	16.79324	33.5865	50.3797	67.1730	83.9662	100.7594	117.5527	134.3459	151.1392
15 1/4	17.19546	34.3909	51.5864	68.7818	85.9773	103.1728	120.3682	137.5637	154.7591
15 5/16	17.60244	35.2049	52.8073	70.4098	88.0122	105.6146	123.2171	140.8195	158.4220
15 3/8	18.01418	36.0284	54.0425	72.0567	90.0709	108.0851	126.0992	144.1134	162.1276
15 7/16	18.43068	36.8614	55.2920	73.7227	92.1534	110.5841	129.0147	147.4454	165.8761
15 1/2	18.85194	37.7039	56.5558	75.4077	94.2597	113.1116	131.9636	150.8155	169.6674
15 9/16	19.27795	38.5559	57.8339	77.1118	96.3898	115.6677	134.9457	154.2236	173.5016
15 5/8	19.70873	39.4175	59.1262	78.8349	98.5437	118.2524	137.9611	157.6699	177.3786
15 11/16	20.14427	40.2885	60.4328	80.5771	100.7214	120.8656	141.0099	161.1542	181.2985
15 3/4	20.58457	41.1691	61.7537	82.3383	102.9229	123.5074	144.0920	164.6766	185.2611
15 13/16	21.02963	42.0593	63.0889	84.1185	105.1482	126.1778	147.2074	168.2370	189.2667
15 7/8	21.47945	42.9589	64.4383	85.9178	107.3972	128.8767	150.3561	171.8356	193.3150
15 15/16	21.93403	43.8681	65.8021	87.7361	109.6701	131.6042	153.5382	175.4722	197.4063
16	22.39337	44.7867	67.1801	89.5735	111.9668	134.3602	156.7536	179.1469	201.5403
16 1/16	22.85747	45.7149	68.5724	91.4299	114.2873	137.1448	160.0023	182.8597	205.7172
16 1/8	23.32633	46.6527	69.9790	93.3053	116.6316	139.9580	163.2843	186.6106	209.9369
16 3/16	23.79994	47.5999	71.3998	95.1998	118.9997	142.7997	166.5996	190.3996	214.1995

HOW TO USE THE TABLE — Enter the column headed "Diameter of Cylinder" at the point representing the diameter of the cylinder in question. Move to the right until the column headed by the correct piston speed is reached. Read directly the engine constant, which, when multiplied by the average of the mean effective pressures of the two ends, will give the indicated horsepower of the engine. Deduct from the constant as found above one-half the constant corresponding to the diameter of the piston rod, if accuracy is desired. In the event that a tail rod is used equal to the piston rod in diameter, the rod constant and not one-half of it should be deducted from the cylinder constant before multiplying by the mean effective pressure. For piston diameters not given in the table, the corresponding constant may be found by interpolation, as may, likewise, the constant for a piston rod of a diameter not shown.

Feed-Pump Governor for Severe Conditions of Steel Plant

By C. J. Smith
Steam Engineer, Inland Steel Company

In *Power's* description of the Inland Steel Co.'s Plant No. 2, on page 566 of the April 11 issue, mention was made of the difficulty experienced with the feed-water regulators on account of the constantly changing differential between the feed-water pressure and the boiler-steam pressure. This condition is especially troublesome in a steel plant, of course, because of the wide and quick variations in steam demand. The special pump governor that was designed and built to meet the situation was touched upon very briefly, and as it successfully eliminated the trouble, a more complete description should be of interest.



DIFFERENTIAL PUMP GOVERNOR WITH MERCURY COUNTERBALANCED DIAPHRAGM

With boiler-steam pressure above the diaphragm and feed-water pressure below it, the right differential between the two pressures is maintained by the valve, which controls the steam supply of the feed-water pumps.

As stated in the article, the feed-water pumping equipment at the plant consists of four steam-turbine-driven centrifugal pumps, two rated at 475 gal. per min. each and two at 1,000 gal. per min. each. All the boilers are equipped with automatic feed-water regulators, and the pumps with standard differential pump governors.

After a thorough investigation it was found that the trouble was due mainly to the pump governors, which did not function properly, and so caused surging in the speed of the turbines and pumps, which in turn produced variation in the differential between the feed-water and boiler-steam pressures. It was decided to design and build a governor sensitive enough so that it alone would handle all the pumps and maintain a constant differential pressure on the feed water, irrespective of whether one pump was running at 25 per cent of rating or all four pumps at rating.

The illustration shows the construction of the governor, which was installed in the 6-in. feed-pump steam header. The results obtained were excellent.

The governor was put in operation in this plant eighteen months ago, and up to the present time it has operated continuously without any attention whatever and apparently will continue to do so indefinitely. The feed-water regulator troubles and practically all turbine and pump trouble ended. From the time the governor was installed, one of the smaller boiler-feed pumps was operated continuously for one year without stopping, and an inspection after the run showed it to be in good condition.

The valve, shown at the top in the cut, is of the ordinary double-ported piston type. Instead of using the customary double poppet valve, a gridiron piston valve was adopted to eliminate all unbalancing due to the impact of the steam on the poppet-valve discs. For this service a little leakage makes no difference, and so the valve piston was machined to a fairly loose sliding fit in the valve sleeve, thus eliminating practically all friction at this point. The valve piston is connected by its stem to a flexible rubber diaphragm. A short pipe connects the valve body to the diaphragm casing and admits inlet steam pressure to the top side of the diaphragm. The lower side of the diaphragm casing is connected by a small tube to the bottom of the mercury pot, the top of which is connected to the feed-water main. The governor valve is placed in the steam header serving the pumps, with the steam going through in the direction of the arrows. The mercury pot should be located at the proper distance below the diaphragm casing so that the vertical distance between the diaphragm and the mercury level in the pot, expressed in mercury head, is equivalent to the differential, or excess, pressure it is desired to carry on the feed water above the boiler pressure.

In the drawing the valve is shown in the wide-open position, allowing a full head of steam to pass through to the pumps. The inlet-steam pressure, corresponding to the boiler pressure, is communicated to the top of the diaphragm through the pipe attached to the valve body. With the valve open, as shown, the pumps will speed up until the water pressure in the feed main reaches the point where it will overcome the steam pressure plus the mercury head. Then the valve, actuated by the diaphragm, will close to a point where only the amount of steam necessary to maintain a balance is passed to the pumps. If the steam pressure decreases, the water pressure, acting on the diaphragm, closes the valve to the point where the amount of steam passed reduces the feed main pressure an equivalent amount. Thus the valve is automatically maintained in the correct position to assure a constant differential pressure.

In this governor there are no springs, levers, counterweights and stuffing boxes to give trouble, and practically all friction and wear is eliminated. The quickness of action can be controlled to a nicety by regulating the needle valve in the water-pressure pipe.

The diaphragm is made from a good grade of rubber sheet ¼ in. thick. It has been found that it shows practically no deterioration after three years' use in this class of service.

EDITORIALS

Hydraulic Exceed Steam Units in Size

FOR many years the capacities of large steam turbines exceeded those of the hydro-electric units. The two forty-five-thousand-kilowatt steam turbines installed in Detroit are the largest single-cylinder machines in this country and are equaled in capacity by the five hydraulic turbines being placed in the Queenston plant of the Hydro-Electric Commission of Ontario. When the three seventy-thousand horsepower units are installed by the Niagara Falls Power Company, the laurels for capacity in a single unit will have passed to the hydraulic turbine. If the present tendencies in the design of single-cylinder steam turbines in this country are to be taken as a criterion, there is not likely to be any material increase in size of these machines in the near future.

The conditions are so different in the two classes of machines that there can scarcely be any comparison made of the engineering problem involved in each. One operates at very high speed and is subjected to wide ranges of temperatures, in some cases exceeding six hundred degrees. In the other the speed is slow and the temperature low, and it is probably for this reason that the large hydraulic turbine has proved more durable and reliable than the steam unit. Although the hydraulic unit has not been entirely free from serious difficulties, these have been comparatively few. The two most difficult problems with the hydraulic turbine, the thrust bearing and regulation, have been worked out to a high degree of satisfaction, and the operating records of many of these large machines have been such as to inspire confidence in their reliability.

After a few more years of experience with the large steam turbine it may be that the problems in its design and operation will be so well worked out that the operating companies will consider it advisable to install larger machines than the present limit, and we may again see the single-cylinder machine exceed the hydraulic units in size. There is apparently no limit to the size of either type of machine that may be constructed, other than that of transportation, a system large enough to operate them on and the confidence of the operating companies.

A Modern Diesel Power Plant

THE inherent high thermal efficiency of the Diesel engine has been the basic reason for the general disregard of the value of a well-planned installation since the efficiency is well maintained regardless of the details of plant design. The general tendency in the past to avoid all possible accessories has led to serious damage to the machine and has given the Diesel engine a reputation of being expensive to maintain.

One of the objections often raised has been the likelihood of cylinder head or piston fracture. Almost all of such occurrences can be traced to poor cooling water. Engines have been run with cooling water of the worst possible character, and the minerals in this water have settled upon the head and liners, resulting in fractures that were both costly and inexcusable.

The necessity of pure water for cooling purposes has come to be understood, and while scores of Diesel and semi-Diesel engines are still called upon to use a poor quality of cooling water, the larger plants are usually provided with a cooling system in which only pure water passes through the engine. The trouble with fractured heads and liners has since disappeared.

The plan generally followed in plants of from one hundred to one thousand horsepower embodies a closed system of cooling whereby the same clean water is used over and over again, being cooled in some form of condenser by raw water. Many plants have adopted a system quite like the atmospheric condenser of the refrigerating plant where the pure water flows through a set of coils and the raw cold water flows down over the outside of the coils. This is quite suitable for a small plant, but the coils are altogether too large and costly for plants where the capacity runs into thousands of horsepower.

In the Calumet Diesel stand-by plant of the Chicago Sanitary District, described on another page, a shell and tube cooler was adopted. This cooler is made up of a cast-iron cylinder into which is nested a set of tubes through which the engine cooling water passes while the raw water from the river flows around the tubes. The high velocity of flow through this cooler allowed the designer to make the dimensions fairly small, in marked contrast to the space required by the atmospheric type. Engineers will find in the Calumet plant much of interest beyond the cooling system.

It is now understood that the ability of an engine to burn heavy oil depends on the viscosity of the fuel in question. If by heat treatment the viscosity is lowered to a point where the oil can be pumped readily, the engine will operate satisfactorily on the heaviest of boiler oil. This is especially true of the two-cycle engine. In the Calumet plant oil temperers are provided with the idea of enabling the plant to use the most available oil regardless of its gravity or viscosity. These temperers are merely heaters in the engine exhaust line where water is heated and afterward used to warm the fuel oil. A similar arrangement in any Diesel plant will widen the range of available oils and permit the use of even the cheap Mexican boiler oil, which is now sold at less than one-half the price of refined Diesel oils. Such a system would be of especial benefit to plants along the Atlantic Coast where the high prices of refined oils have delayed the more general use of Diesel engines.

"Accuracy" in Boiler Tests and Other Things

SOME people who talk about "exact" work or measurement apparently have the idea that the absolute meaning of the word can be used in connection with material things. The carpenter draws a line across a board with his square and pencil and then saws "exactly to the line." The machinist turns a shaft to a diameter of "exactly" one inch. An expert toolmaker might insist

that the same shaft was exactly 1.0001 in., while such an able exponent of precision as the late John Brashear might say that neither he nor anyone else could tell the exact diameter, but that he could find the diameter—at a certain point and at a certain temperature—to the nearest hundred-thousandth of an inch.

The true meaning of accuracy in measurements and computations is not so clearly understood by the average engineer as it might be. Here he might learn something from the scientists, who are thoroughly drilled in this matter and consider no piece of scientific work complete without an indication of the estimated degree of accuracy of the results obtained. This does not necessarily require a long-winded statement; the manner of writing the answer can be made to tell the story. In ordinary arithmetic 1.00 inch means the same thing as 1.0000 inch, but in scientific work they mean two quite different things. In the latter, 1.00 is a way of saying that the answer appears to be 1.00 to two places of decimals, but cannot be trusted beyond the first place of decimals. When, on the other hand, the scientist writes 1.0000 inch he thereby implies that the answer figures 1.0000 to the fourth decimal place but is probably correct to the third only. In other words, the man writing 1.0000 inch is really claiming that his result is one hundred times as accurate as that of the man who writes 1.00 inch, provided that both of them follow the established custom of going one decimal place beyond the last reliable figure.

While some engineers are as careful in this matter as are the workers in pure science, many others continue to carry the results of their computations several decimal places beyond the point where they mean anything. This is usually due to thoughtlessness rather than to any attempt to deceive.

In his paper, "The Accuracy of Boiler Tests," presented at the Spring meeting of the A. S. M. E., Alfred Cotton heaped ridicule upon the custom of reporting boiler efficiencies to two places of decimals. If it is the case, as he stated, that the efficiency determined by a carefully conducted twelve-hour test on a coal-fired boiler may easily be in error by two or three per cent, it is certainly misleading to talk about obtaining an efficiency of, say, 71.32 per cent. The first place of decimals is perhaps worth putting down, but nothing more than 71.3 would be justified.

Reliability vs. Economy

THE last few years have witnessed intensive development of the steam turbine and units of thirty and thirty-five thousand kilowatts capacity are now almost becoming standard for large central stations. Along with this there is a tendency to reduce reserve capacity, especially where advantage can be taken of system interconnection, and to operate the large economical plants on base load. Such practice, in principle at least, is good engineering; it should stand for minimum investment, sufficient reliability and economical generation. The extent to which these objects are attained, however, depends upon the proper functioning of all factors concerned.

Base load service carries with it a high demand factor, and if the equipment is not ready at all times to meet this demand it must be met with the less economical units, and in addition carry the enormous fixed charges of the larger units while they are idle—a condition which may easily outweigh the expected economies from the units selected.

The survey made by the Prime Movers Committee of the National Electric Light Association, covering about fifty per cent of the large turbo-generators of the country, shows a surprisingly large outage factor, especially those operating on base load, although it must not be overlooked that there were a few instances in which very creditable records were shown. The committee might have gone a step further and classified the causes of these outages, for the problem is a joint one of manufacturer and user.

There is at present a decided inclination among users to adopt the slogan, "Reliability first, economy second" with a realization that this means, everything considered, greater saving in dollars and cents.

Adequate Working Space

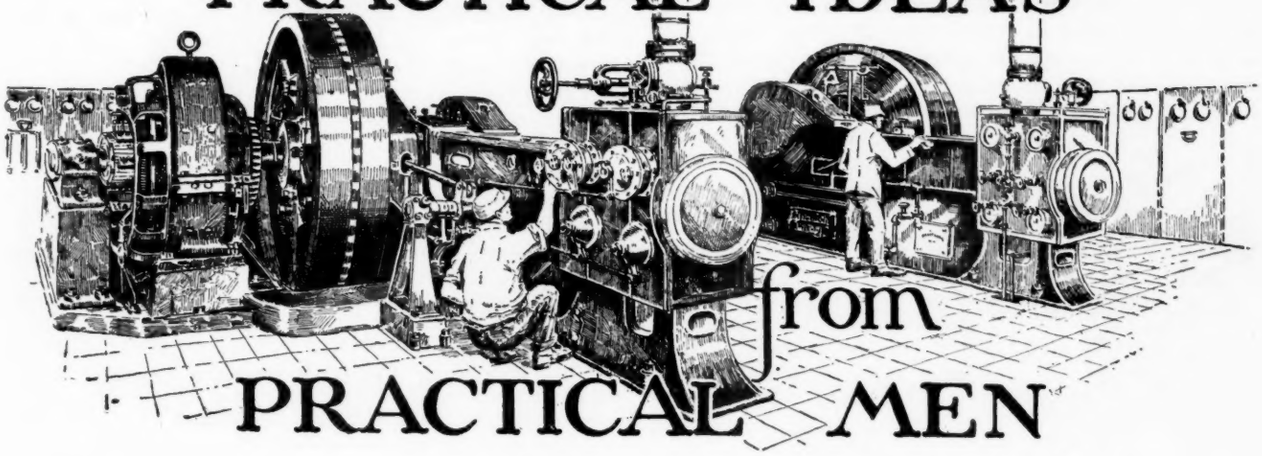
GENEROUS allowance overhead is recognized as essential in good modern plant design. It is recognized that this space, although not actively used except occasionally, is worth much more, as affording light and air, than the extra cost involved. The same principle is not so generally recognized in considering floor area and side clearances. There is a tendency to install equipment as close to a wall as possible so that the maximum number of units may be introduced in a building of given size or, what is really equivalent, the building may be made of the minimum floor area. There is more justification for this economy in floor area than there is for equivalent economy in height, because an addition to the floor space increases not merely the length of the wall but also the area of foundations and roof, which are often two of the most expensive parts of the structure. Moreover, the land available is often limited, and hence it also must be carefully considered. However, it is quite possible to economize too far in this direction.

Ample working space about equipment for the operators is the first requirement for safety. A man should not be required to climb over apparatus for the purpose of lubricating and for inspection, especially when these operations must be performed while the apparatus is running. Substantial and suitably spaced passageways should always be provided, even around parts that need be visited only at infrequent intervals.

The generous allowance of side clearance both between units and the wall and between adjoining units will be especially appreciated at times when repair or adjustment work is necessary. Nothing is so expensive as repair work done under conditions that are uncomfortable for the repair man. The work drags and its quality suffers severely. In some cases the extra cost for repairs within a few years will quite equal the extra cost involved in providing adequate space at the outset. In addition to the actual money advantage, there is the indirect advantage of giving all operating men comfortable and attractive working surroundings. The clear, orderly effect produced by proper spacing and generous passageways will do much to maintain the morale of a working force.

C. W. E. Clarke's paper on "Performance at Colfax," before the A. S. M. E. at Atlanta not only was a valuable contribution to power-plant knowledge, but set a precedent for which the Duquesne Light Company is to be commended. Could it be that the lack of discussion of this paper at Atlanta was due to reluctance of other companies to follow the example?

PRACTICAL IDEAS from PRACTICAL MEN



Shifting the Load on A.C. Generators

A number of years ago, while making a study of a small industrial power plant operating two three-phase engine-driven generators, I found that the engineer in charge had for a number of years been shifting the load, as he supposed, by manipulating the generator field rheostats, while in reality he was only changing the reading of the ammeter.

There was no wattmeter on the switchboard, but there was an ammeter in each generator circuit, and cutting in the field resistance of course reduced the ammeter reading considerably. This to the engineer was evidence enough that he was taking off the load, and as the units were small this method of operation had always been satisfactory.

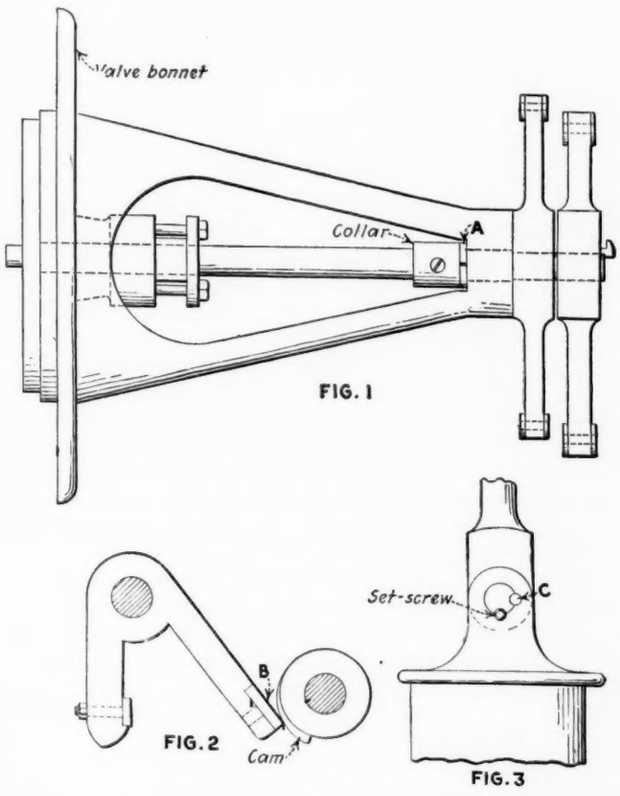
After trying to explain in electrical terms why variation in excitation had no effect on the load, I suggested to the engineer that we set up the indicator and take diagrams both before and after he had shifted the load in the usual way. This was a test that he could understand, and when the two sets of diagrams showed the same indicated horsepower, he was satisfied that he could not shift the load from one unit to the other by simply operating the field rheostat.

Holyoke, Mass. ARTHUR S. WELLS.

Reducing Lost Motion on Valve Gear

The majority of operating engineers strive to maintain quiet running of engines under their charge. In most of the older types of Corliss valve gear there are quite a number of wearing parts, and a little lost motion in each part produces a disagreeable noise, most of which may be eliminated by "keying up." But there are some parts where the lost motion cannot be taken up in that way.

After long wear, the bearing faces of the release lever and bell crank, carried on the end of the steam-valve stem, become worn. In some cases this is sufficient to disturb the position of the cutoff cam. If the wear is not excessive, the bell crank may be pushed back on the valve stem and keyed up, or the end lash can be eliminated by making a split washer of soft iron and inserting it between the collar and the bearing as shown at *A*, Fig. 1. By this method the dashpot rod is not thrown out of plumb and the end lash on the valve stem is taken up. On the old-style crabclaw a steel wearing plate, as shown at *B*, Fig. 2, is riveted on the end that comes in contact with the cutoff cam. If these are replaced with fiber plates, they will wear a long time and do away with a disagreeable "click."



FIGS. 1 TO 3. SIMPLE METHODS OF ELIMINATING NOISE AND LOST-MOTION ON VALVE GEAR

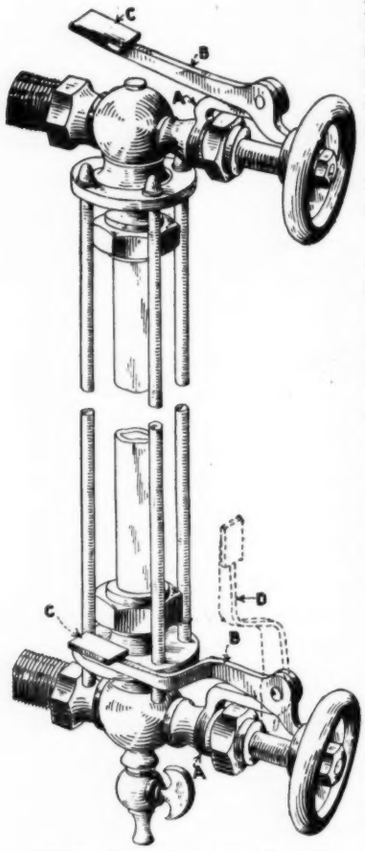
Fig. 1—Split washer placed between collar and bearing removes end-play of valve stem. Fig. 2—Steel knock-off plates on crabclaw replaced with fiber. Fig. 3—Lost motion in brasses taken up by giving pin one quarter turn.

On some engines no provision is made for taking up the lost motion in the brasses on the lower end of the dashpot rod. This can often be done by giving the pin one-quarter turn and drilling and tapping a new hole for the setscrew as shown at *C*, Fig. 3.

Camden, Me. M. M. BROWN.

A Safety Telltale for Water Gage

Most engineers have at some time closed the cocks on the water gage and forgotten all about them until some sense of danger prompted them to remember that the gage was not showing the correct water level in the boiler. A leaky valve will at times allow the gage to fill to the water level, but as the boiler supply works down, the glass does not drain and the result is a showing of plenty of water while the real supply in the boiler is at the danger line.



WHEN VALVES ARE CLOSED ARMS STAND VERTICAL AND IN VIEW OF FIREMAN

A very simple device and one that is easily made may be installed on a gage to show plainly at any distance at which the gage can be seen whether the valves are open or closed. Make two clips, as shown at *A*, to fit over the stuffing box of the valve stem. These clips carry the arms *B* made of $\frac{1}{16}$-in. sheet metal and about three inches long. The lower arm is offset so as not to interfere with the gage glass. On the end of each arm *B* is fastened a small piece of sheet metal *C*, painted bright red.

To install this telltale, remove the handwheel and the packing nut and screw on a locknut, then place the clip *A* over the threads and replace the packing nut. Put more packing around the valve stem if necessary, so that the nut will not have to be placed on so far. The arms are then drilled so that they will stand in a vertical position, as shown at *D*, when the valve is closed. Then, as the valve is opened, the arm will lie down. This will show at a glance whether the valve is open or closed and to what amount.

G. H. McVICKER.

North Bend, Neb.

Among the Oil Derricks

The night shift had just finished eating. Buster, the new oiler, started to wipe up No. 4, a four-cylinder 600-hp. gas engine. Starting on the upper deck, his foot slipped and gently touched a crowbar that someone, forgetting the safety first rules, had left on the deck. Overboard went the crowbar and coming in contact with the ignition timer, broke it into atoms. Buster called the night chief, who in turn called the repairman. A pow-wow was held, and it was decided to call out the Old Man, who came in twenty minutes later, blinking and trying to kid himself into believing that he was feeling fine.

The broken timer was shown to him and he immediately said: "No use, boys, wasting any time on that one—it's finished. Let's see what we can rig up till a new one comes, as No. 4 has to run by 5:30 or no street cars tomorrow."

The foregoing, if read by the superintendent, might explain several things, as he never could understand why anyone would want to steal the timer off his Ford car and not touch tools, etc.

The above happened five years ago, and this engine is still doing business with a Ford timer.

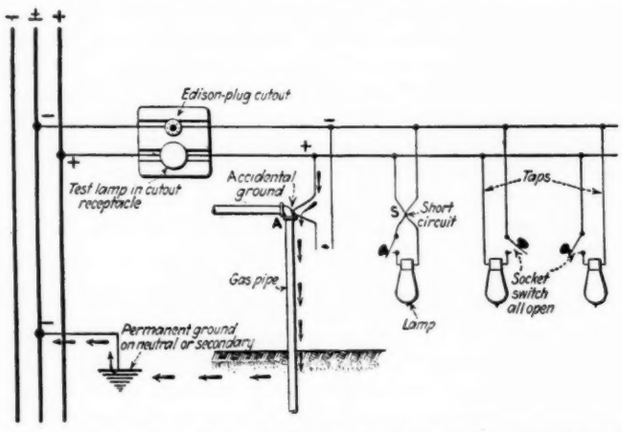
Boys, open your dictionary and cut out the words, "It can't be done."

BARNEY MEYER.

Tulsa, Okla.

Finding Trouble with a Lamp in a Fuse Block

An incandescent lamp can be used for testing lighting circuits, by replacing one of the fuses in the cutout or fuse block with the lamp. When tests are being made in this way, the lamp is inserted in the fuse receptacle in the cutout on the ungrounded side of the circuit. The lamp serves not only as an indicator, but also as a resistance, which limits the current through the circuit. In case of a short-circuit, as at *S*, the test lamp will light. Or with a ground as at *A*, the lamp will light also. Trouble can thus be localized by first putting the lamp in a service entrance cutout plug with all the branch circuits connected. In the case of a ground or short-circuit, as suggested in the illustration, the lamp will light. Then both sides of each of the branch circuits are successively opened until the lamp goes out. This localizes the trouble to a single branch circuit. Now the difficulty can be further localized by screwing the indicating lamp in the cutout that



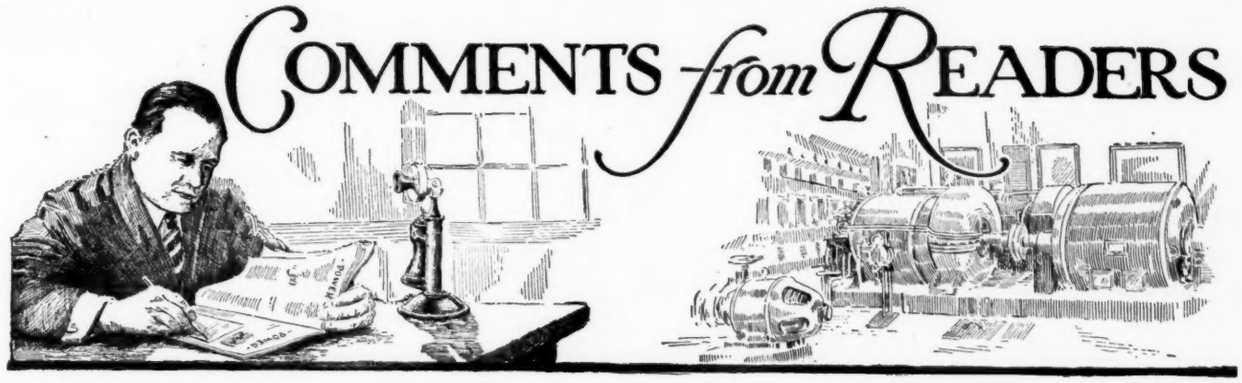
TESTING FOR FAULTS WITH LAMP IN FUSE RECEPTACLE

serves the branch circuit, making test as previously suggested.

In locating trouble by this method, all the incandescent lamps or their receiving devices on the circuits under test must be opened by the socket or the individual switches through which they are fed. The underlying principle of finding the trouble is that of elimination. With the test lamp in position in the cutout, disconnect circuits or parts of circuits until that circuit or the part of the circuit in which the trouble exists is identified.

J. C. COLONNA.

St. Louis, Mo.



Why Do the Piston Rings Break?

In the Feb. 28 issue Mr. Hilliary asks for suggestions as to the probable cause of piston rings breaking.

In the operation of small horizontal engines, such as he refers to, it is not considered good practice to use steam of 540 deg. F. temperature, as the wear on the bottom of the cylinder is likely to be excessive at that temperature.

If he will fit a bronze junk ring to the piston the next time the cylinder is rebored, it will stop the wear on the bottom of the cylinder if the metal in the cylinder is of good quality. I have fitted high-pressure pistons with rings made of bronze called Jenkins metal. This metal takes on a high polish and gives good service.

It is also important that a high-grade cylinder oil be used and delivered at the center of the steam flow.

Vancouver, B. C., Canada. W. A. COOIL.

Measuring Corrosiveness of Water

I have read with great interest the article of April 25, entitled "Portable Kit Measures Corrosiveness of Water," because I have just finished the oxygen determination at two of our stations. Samples of steam and water were taken at different places in the cycle of operation in order to ascertain which part of the system was most affected by the dissolved oxygen.

There are a few statements in the article which I wish to discuss at present. You say, "When the oxygen is gone, corrosion stops, even though the water contains other impurities." A number of impurities will cause "corrosion." For instance, CO_2 forms carbonic acid when dissolved in water and is very corrosive in nature. The method of determining the amount of dissolved oxygen will not show the quantity of CO_2 in the sample under analysis. Where boiler-feed water is treated with sodium carbonate, for instance, and the latter is in excess of the amount required for treatment, CO_2 is liberated. I took a number of steam samples and found some of them to contain CO_2 and no oxygen.

I am not in favor of your method of taking samples. If suction is applied to the bottle in which the sample is collected, the pressure will be reduced and some of the dissolved gases liberated. Furthermore, if the sampling flask of 500 c.c. capacity is full of air and the water or steam sample (free of air or containing only a small amount) is passed through the flask in the manner described, much of the 500 c.c. of air will be absorbed. In order to reduce this amount of absorbed air (to free the sample of it is practically impossible), many times 500 c.c. of water must be passed through the flask, as an air-free sample can be obtained only by continuous dilution for a long period.

The addition of $MnCl_2$ through a funnel tube that is inserted through the stopper may cause a great error. The object of the test is to raise the valance of the $MnCl_2$, in other words, to oxidize it by the oxygen in the water under analysis. Now, if the funnel is filled and the solution of $MnCl_2$ slowly taken up by the water samples, absorption of oxygen from the air at the surface of the mixture in the funnel stem will take place, thus introducing an error. It is especially at this point that great care should be taken not to absorb any oxygen from the air.

To "measure out with the graduate *exactly* 250 c.c. of the treated sample, etc.," is not correct in my estimation. In the first place a graduate is not a desirable piece of apparatus for measuring with exactness. Why not use a volumetric flask? Furthermore, the operator should take into consideration the amount of the three reagents previously added; thus he should take 253 c.c. instead of 250 c.c.

The amount of sulphuric acid to be added should be slightly in excess of that just required to dissolve the precipitate formed by the other reagents. Sometimes it may be found that 2 c.c. is not sufficient to dissolve the precipitate. If a 500 c.c. sample is taken (better 1,000 c.c.) and 250 c.c. used for analysis, then one-half the amount of the reagents added should be measured out with the 250 c.c. sample.

Referring to the part of the last paragraph reading, "Samples that are above the temperature of the atmosphere . . . should be led through a copper tube cooled with water," the copper tube is objectionable. I collected a number of steam samples which I cooled through a copper coil. The tests showed that the steam contained 0.63 c.c. of dissolved oxygen per liter. I suspected that the copper coil caused this high result and therefore replaced it by a glass coil. The results showed no oxygen at all in most of the steam samples and only traces in some of them. The copper oxide formed inside the copper coil must have caused the high results.

The starch indicator should be added toward the end point of the titration, when the yellow-brown color produced by the iodine is nearly removed, as a much more delicate end point may then be obtained. It is also essential that the same amount of starch be added to the chemically treated sample, as varying amounts of starch solution will give varying results.

I agree that great care should be exercised in taking the samples for analysis, and that the samples should be protected from the air. G. A. DE GRAFF, Chemist.

Newark, N. J. Public Service Electric Co.

QUESTIONS AND ANSWERS

Distinguishing Iron from Steel Boiler Brace

How may it be known from inspection of a boiler brace in place whether it is made from iron or steel?

W. W.

By filing a bright spot on the material and applying a strong acid, the etching on an iron brace would show laminations of the material, while the brightened surface on a steel brace would show a homogeneous structure of the material.

Drop System of Steam Heating

How is the piping arranged in a drop system of steam heating?

A. B. H.

The term "drop system," or "down feed," generally is employed to designate a heating system with overhead distribution of steam or hot water in which the feed main is carried from the boiler direct to the highest story of the building, where branches are extended to vertical distribution pipes or risers. This system of piping, when properly designed, gives excellent circulation and generally is adopted to save the presence of large distributing mains and branches on the ceiling of the basement, and also to obtain smaller sizes of the distribution risers that are extended through the lower stories of the building.

Crystallization of Pipe Material from Exposure to Weather

A shipment of steel pipe that was ordered by our company was allowed to remain exposed to the weather for several months in a warm climate. The pipe proved to be defective, and it was claimed that the material became crystallized from exposure to heat of the sun. Would such exposure produce crystallization?

H. J. L.

Crystalline arrangement of the material usually results from repeated shocks or vibrations, or may be a disintegration from electrolysis partaking of the form of a granular structure, or may result from very high temperatures. Recrystallization of low-carbon steel does not occur for a temperature of less than about 800 deg. F. It is not probable that noticeable deterioration of the kind would occur to good pipe material from natural changes of temperature of the atmosphere.

Metallic Paper for Indicator Diagrams

How can paper be prepared to receive marks of a metallic point in place of a lead pencil for taking indicator diagrams?

C. N. D.

A smooth unsized writing paper can be prepared to receive markings of a soft brass or aluminum pencil by covering the surface of the paper with a coating of zinc white, which can be purchased at almost any drug store or paint shop. The zinc white is to be mixed with common mucilage and water into a thin paint which should be strained through cheese cloth to remove any lumps and brushed on the paper in a single light even coat. Before the prepared paper is used, it should be perfectly dry. The metallic pencil may have its marking point drawn down to a small size, but the very end should be rounded so the point will make a mark for a gentle pressure without digging into the paper.

Pump Trouble with Suction from Open Heater

We have considerable annoyance from slipping and pounding of our boiler-feed pump which takes suction from an open feed-water heater that is about two feet above the level of the pump. What is recommended for the trouble?

J. W. S.

The most certain remedy would be to set the pump eight to ten feet lower, to insure delivery of the hot suction water to the pump chamber above the pressure of the atmosphere, using a suction pipe at least as large as the suction connection on the pump, to reduce loss of pressure in the suction pipe from pipe friction. Conditions may be such that the trouble would be removed by simply placing an open standpipe on a tee in the suction pipe close to the pump, making the standpipe and its connection at least the full size of the pump suction, and extending the standpipe about a foot higher than the water level in the heater. Also a larger suction pipe would be beneficial, by reducing the loss of pressure from pipe friction.

Allowance for Quality of Steam

Where a non-condensing engine under a stated load is guaranteed to have a steam consumption of 24 lb. of dry steam per indicated horsepower-hour supplied at stated pressure, and the actual quality of the steam used is only 96 per cent dry, what consumption of steam of quality actually supplied would fulfill the guarantee?

R. L. B.

Each pound of the wet steam as supplied would consist of 0.96 lb. of dry steam and 0.04 lb. of water; and the guarantee would be fulfilled for consumption of $24 \div 0.96 = 25$ lb. of the wet steam per indicated horsepower-hour. The consumption of actual dry steam will be the same for any reasonable variation of the proportion of moisture present. Experiments have shown that introduction of water in proportions from 1 to 42 per cent is practically without influence and that the water remains inert, neither helping nor hindering the dry steam consumption.

Clattering Noise with Light Load

During part of each day our 22 x 42-in. non-condensing Corliss engine must be run with a very little load, and at such times there is a bad clattering in the cylinder. How can the noise be prevented.?

R. B. M.

Operation of the engine should be studied from indicator diagrams taken under the different conditions of loading. The noise with the light load probably arises from cutting off so short that expansion goes below the pressure of the atmosphere. Trouble from that cause may be prevented by sufficiently throttling the admission pressure to obtain later cutoff. If the desired result cannot be obtained in that manner, then at a small expense of economy, the terminal pressure can be prevented from going too low by connecting together the indicator connections of opposite ends of the cylinder with a stop valve in between, left open no more than necessary to stop clattering of the engine valves, or by leaving the cylinder cocks open a little to the atmosphere.

Proximate Analysis of Coal

What is the proximate analysis of coal and how do the results compare in their practical value with results obtained by an ultimate analysis? R. N. D.

The proximate analysis gives the proportion of fixed carbon, volatile, combustible, moisture and ash, and affords information of the general characteristics of a coal and for comparing the value of different lots of the same kind of coal.

The proximate analysis is made by subjecting a sample to a temperature of 250 to 300 deg. F. to expel the moisture; then to a red heat, which expels the volatile matter; then to a white heat, which causes the carbon to pass off as a dioxide, leaving the ash as a final residue. By weighing the residue at the end of each operation, the various percentages can be estimated.

The heat value of the fuel cannot be directly computed from the proximate analysis, as the volatile content varies in composition and heat value. Hence the proximate analysis does not furnish information for computing the heat of combustion with the same degree of accuracy as an ultimate analysis, but estimates that are sufficiently correct for most practical purposes may be based on the proximate analysis.

Reconnecting an Induction Motor

A 10 hp. three-phase induction motor wound for operation on 220 volts is to be operated on a 110-volt circuit. The motor has 72 coils grouped for a 6-pole winding, connected double-delta. Is it practical to regroup the coils for 110-volt operation, either by connecting the polephase groups in parallel or by paralleling the coils in each pole group? R. O. W.

As the winding is now connected, each phase is divided in two parts of three pole-phase groups in series and these two groups connected in parallel. Since the voltage is to be reduced by one-half, the number of coils in series should be divided by 2. This would require connecting the winding 4-parallel delta. The winding has 6 pole-phase groups per phase and dividing these by four gives $1\frac{1}{2}$ groups per circuit. On account of the voltage generated in one-half of a pole-phase group being out of phase with the voltage in the other half, it is not possible to connect two half groups in parallel without having circulating currents in the windings. For the same reason it is not possible to connect the coils in any pole-phase group in parallel. Therefore the motor in question cannot be operated on one-half the original voltage without rewinding the coils with one-half the number of turns of double the size of wire, as in the 220-volt winding, or some equivalent of one-half the number of turns and a double-delta connection, such as wind the coils with $\frac{3}{4}$ the number of turns of $1\frac{1}{8}$ times the original size wire and connect the winding 3-parallel delta.

Flow of Water Through 10-In. Pipe

What is the velocity of water flowing through a 10-in. iron pipe where the pressure at points in the line 75 ft. apart are 20 and 17 lb. per sq.in. C. H. M.

The rate of flow corresponding with the drop of pressure would depend on the roughness of the pipe and on the number of bends, fittings or obstructions; but assuming that the pipe is fairly clear and straight, based on experiments, this loss of pressure, namely, 3 lb., or loss of head of $3 \times 2.3 = 6.9$ ft., would be due to discharge at the rate of about 3,600 gal. per min., which would correspond to a velocity of 882 ft. per min. This estimate is based on the assumption that the drop of pressure is correctly taken at $20 - 17 = 3$ lb., and it should be borne in mind that estimates of pipe flow cannot be regarded as closer than 5 per cent because of the difficulty of knowing whether the pipe surfaces are in the same condition as pipes on which the formulas have been constructed.

Hunting Action of Governor

What causes the irregularity of speed following a change of load of an engine? R. H.

When there is a change of load, there is an alteration of speed of the engine and the governor cannot act immediately, because it only can operate after a change of speed has occurred. Then a change in position of the governor does not affect the change of speed of the engine immediately, both on account of the inertia of the moving parts of the engine, which has the effect of resisting a change of speed, and also because of the energy contained in the steam that has passed the control of the governor. In case of a throttling governor the steam chest is filled with steam at the time the change of speed begins, and if the governor acts upon the cutoff its opportunity for controlling the speed has passed if cutoff has occurred. Hence there is a time lag between the governor and the engine speed. If the governor is too sensitive, then by the time the change in engine speed has had full effect on the governor, it is forced into a position of over control; that is, a position beyond that which is necessary to bring the engine speed back to normal. The engine speed then begins to change in the opposite direction, and for the same reasons the governor is forced into a position of over-control in the reverse direction.

A state of oscillation is thus set up, which causes the speed to be first too high and then too low—a condition known as "hunting," which can be reduced to a minimum by not having the governor too sensitive and also by dashpots attached to the governor in such a manner as to dampen its motion.

A.S.M.E. Enjoys Southern Hospitality

THE Spring Meeting of the American Society of Mechanical Engineers, held at Atlanta, Ga., May 8-11, will be remembered not as the largest, but as one of the most enjoyable of these annual gatherings of the Society. While the registration failed to reach 350, the entire country from St. Paul to Galveston and from the Atlantic to the Pacific Coasts was represented, and the tactful solicitude of not only the local committee but the industries and citizenry of Atlanta that every individual guest should enjoy every moment of his stay resulted in an occasion of which all who had the good fortune to participate will retain the most pleasant memories.

Education Discussed at Charlottesville

The Virginia Section had arranged a joint meeting with the Society for the Promotion of Engineering Education and the Virginia sections of the American Society of Civil Engineers, the American Institute of Electrical Engineers, and the Richmond Chapter of the American Association of Engineers at Charlottesville for Friday and Saturday, May 5 and 6. This was attended by the president and secretary and numerous members of the Council and Society en route to Atlanta. The sessions were held in Madison Hall of the charming old University created by President Jefferson. Friday morning was devoted to a conference, "How to Organize an Engineering Problem," contributed to by Charles H. Fish, consulting engineer, of Boston; Prof. Joseph E. Rowe, of William and Mary College; E. W. James, assistant chief engineer, United States Bureau of Public Roads; and Prof. Charles Hancock, of the University of Virginia. In the afternoon there was a symposium, "How the Industries Can Aid Engineering Education," in which Prof. Timbie, of Massachusetts Institute of Technology, H. J. Hughes, Dean of Engineering of Harvard University, Prof. James B. Miller, Jr., University of Virginia, Charles L. Reese, of the Dupont Explosives Co., C. F. Kettering, head of the research department of the General Motors Co., Prof. Kenerson, of Brown University, and George A. Orrok, consulting engineer, New York, took part, and to which Dr. Ira N. Hollis, of Worcester Polytechnic Institute, H. L. Seward, W. E. Wickenden, C. R. Dooley and Charles H. Eames contributed written discussion.

In the evening Dexter S. Kimball, president of the A.S.M.E. and Dean of Engineering at Cornell University, delivered a masterly address on "The Content of a Liberal Education." The sessions were gracefully conducted by Dean William M. Thornton, of the University of Virginia.

On Saturday, through the courtesy of the Charlottesville Chamber of Commerce, the visitors were taken by automobile to Monticello, once the home of Thomas Jefferson, and in the afternoon to Rockfish Gap at the crest of the Blue Ridge.

The Sessions in Atlanta

At its business meeting in Atlanta the Society discussed its proposed new constitution and advanced it to its final reading and the form in which it is to be voted upon at the annual meeting. It also considered the Code of Ethics which the leading engineering societies of the country are formulating for general adoption, and the report of its representatives on the American Engineering Council.

The technical sections were well arranged with ample material to employ profitably the time allowed, but without that surfeit which has so discouraged discussion at the meetings. It was remarked that notwithstanding the limited number present, the sessions were all well attended and that interest was sustained until the last.

The program contained several features of particular interest to Power readers. Dr. Johann Stumpf, of the Tech. Hochschule, Charlottenburg, inventor of the unaflow engine, was present and presented, with C. C. Trump under the auspices of the Power Division, a paper upon Using Exhaust Energy in Reciprocating Engines. This is a suggestion for the use of the residual energy due to incomplete expansion to reduce the counter-pressure by the employment of education nozzles, and embodies, a principle that may possibly find a wider application than the authors of the paper intimate. It, as well as the other power papers, will have more extended attention in later issues.

Another paper procured by the Power Division was upon the "Accuracy of Boiler Tests," by Alfred Cotton. This was largely a plea to give up pretenses of impossible accuracy in boiler tests. Mr. Cotton held that it was absurd to report the heat-balance figures of a boiler test closer than the nearest tenth of one per cent. Arguments were presented to show that the efficiency obtained from a carefully conducted twelve-hour test on a coal-fired boiler might easily be in error by 3 or 4 per cent.

At a public hearing by the Committee on Power Test Codes opportunity was offered for final criticism and comment before their formal adoption upon the Code of Definition and Values, Displacement Compressors and Blowers, and Hydraulic Plants and Their Equipment.

At the meeting of the Fuel Division the following papers were presented and discussed: "Reduction of Fuel Wastes in the Steel Industry," by F. G. Cutler; "The Control of Boiler Operation," by E. A. Uehling; and "Boiler-Room Performance and Practice of Colfax Station, Duquesne Light Company,"[1] by C. W. E. Clark of Dwight P. Robinson Company.

Fuel Wastes in the Steel Industry

The paper on the "Reduction of Fuel Wastes in the Steel Industry" gave a survey, in the form of a heat balance, of the heat required and produced by the various operations in the manufacture of iron and steel. This showed that the surplus heat available from the blast-furnace gas and byproduct-coke-oven gas, tar and coke braise produced in making one ton of pig iron should be more than enough to furnish all the heat and power needed to finish the average ton of steel. According to Mr. Cutler the problem was mainly one of proper scheduling and control rather than of the installation of new equipment.

Mr. Uehling, in his paper on the control of boiler operation, stated that the pound of coal would probably continue to be the commercial fuel unit, but was most unsatisfactory as a *control* unit. The pound of combustible was a more satisfactory unit, but even this allowed of considerable variation in the heat value. After a careful study of the hundreds of analyses published by the Government, Mr. Uehling strongly recommended the use of the pound-carbon fuel unit as giving a practically constant heat value. He then proceeded to develop a simple system of figuring the per cent losses and of dividing these losses to show the portions due to various avoidable causes.

In the second General Session R. H. Heilman presented a paper on "Heat Losses from Bare and Covered Wrought-Iron Pipe at Temperatures up to 800 deg. Fahrenheit."[1]

The Power Division had papers from Charles G. Adsit, on "Power Development in the Southeast"; by C. A. Mees, on the "Economics of Water-Power Development"; John A. Sirnit, on "Hydro-electric Power-Plant Design"; and by H. B. Reynolds and W. F. Hovey the report previously presented to the Metropolitan Section and now presented by title only, upon "Efficiency Tests of a 60,000-kw. Cross-Compound Triple-Cylinder Steam Turbine."[2]

Valuable Hydraulic Papers

It is hardly possible to single out for special comment any portion of Mr. Mees' paper, which was a broad outline of the economic and business considerations involved in the financing, construction and operation of complete hydro-electric systems.

Mr. Sirnit's paper dealt almost entirely with the use of the backwater suppressor in hydraulic power plants. In many such plants there is a serious loss of head during flood seasons on account of the rise in the tailwater level. O. G. Thurlow, chief engineer of the Alabama Power Co.,

[1] Abstracted in *Power*, May 16, 1922.
[2] Abstracted in *Power*, March 14, 1922.

conceived the idea of using the water running over the spillway to push back the tailwater and thus reduce the negative head on the discharge of the draft tube. The paper describes various preliminary experiments as well as the application of the Thurlow Backwater Suppressor in connection with the new Mitchell Dam project of the Alabama Power Company.

Under the joint auspices of the Boiler Code Committee and the American Welding Society a symposium on Welding was contributed to by R. J. Roark in a paper on the "Strength of Electrically Welded Pressure Containers"[3]; by S. W. Miller on "Some Principles of the Construction of Unfired Pressure Vessels";[3] by F. N. Speller, on "Steel for Forge Welding"; and by E. A. Fessenden and E. J. Bradford, on "Tests on Welded Cylinders."[3]

That the most important considerations in the uniform production of welds of high efficiency are "suitable material, well-trained operators and adequate facilities for control of the work" was the conclusion reached by Mr. Speller in his paper on "Steel for Forge Welding." The following is a brief outline of some of the more important points of this paper: Soft welding steel should be made especially for the purpose by the bessemer or open-hearth process. It should not contain over 0.05 per cent each of nickel, chromium or silicon, nor more than 0.30 per cent of carbon. Sulphur under 0.05 per cent is not harmful. Phosphorus up to bessemer limits is beneficial. A good welding steel has the self-fluxing property; that is to say, its scale melts and forms a natural welding flux at a temperature about 100 deg. below the burning point of the metal.

Atlanta Entertains Royally

The entertainment features included an informal get-together dinner at the Piedmont, the headquarters hotel, on Monday evening, a dinner dance on the Ansley Roof on Wednesday evening, a barbecue and exhibition golf match at the East Lake Country Club on Wednesday afternoon, a theater party on Thursday afternoon and numerous excursions to points of industrial and other interest. A most charming manifestation of hospitality was the entertainment by several of the residents of Atlanta of small parties of the visitors at their homes. An innovation was the action of the nominating committee in holding open session throughout the week, inviting suggestions of possible nominees for the various offices to be filled and collecting information as to their respective qualifications. The material so collected is systematically recorded not only for the use of the present committee, but to be preserved and transmitted to their successors.

Another new administrative feature was the calling together at breakfast of the presiding officers of the day's sessions and the authors of the papers to be presented. This happy idea of Roy V. Wright, chairman of the Committee on Meetings and Programs, was conducive to a better understanding between the platform and the floor as to the conduct of the meeting and will probably be continued.

New Officers Nominated

The nominating committee finished its deliberations on Monday, May 15, reporting John Lyle Harrington, of the consulting engineering firm of Harrington, Howard & Ash, Kansas City, Mo., as its unanimous choice for president. The other officers nominated are as follows: Vice-presidents—W. S. Finlay, Jr., vice-president, American Water Works and Electric Co., New York City; William H. Kenerson, professor of mechanical engineering, Brown University, Providence, R. I.; Earl F. Scott, president and manager, Earl F. Scott & Co., Atlanta, Ga.; H. H. Vaughan, consulting engineer, Montreal, Que., Canada (to fill the unexpired term of L. E. Strothman, who died recently); Managers—A. G. Christie, associate professor of mechanical engineering, Johns Hopkins University, Baltimore, Md.; James H. Herron, president, The James H. Herron Co., Cleveland, Ohio; Roy V. Wright, editorial department, Simmons-Boardman Publishing Co., New York City; Treasurer—William H. Wiley, president, John Wiley & Sons, Inc., New York City. Delegates to American Engineering Council—John Lyle Harrington, chairman; L. P. Alford, editor of *Management Engineering*, the Ronald Press, New York City; Arthur M. Greene, Jr., professor of mechanical engineering, Rensselær Polytechnic Institute, Troy, N. Y.; Fred J. Miller, consulting engineer, New York City; Max Toltz, mechanical engineer, Toltz, King & Day, Inc., St. Paul, Minn.; Fred R. Low, editor of *Power*, New York City; S. W. Stratton, director of the United States Bureau of Standards, Department of Commerce, Washington, D. C.; Edwards R. Fish, vice-president, Heine Safety Boiler Co., St. Louis, Mo.; Edwin B. Katte, chief engineer of electric traction, N. Y. C. R.R. Co., New York City.

The president and the treasurer are to serve for one year, the three vice-presidents and the nine delegates for two years and the managers for three years. Although these officers will not be formally elected until Sept. 26, the report of the nominating committee is ordinarily followed in full, so that they may be considered the new officers of the Society. They are to be installed at the annual meeting in December.

It was decided that the next spring meeting should be held in Montreal.

The local committee is to be congratulated upon having given a new and charming significance to Atlanta in the minds of all who were so fortunate as to be the subjects of their attention.

[3]Abstracts of these papers will appear in later issues.

France to Put Tides to Work

That France is going to make an energetic effort to try out the practicability of using tidal power is indicated by news from Paris to the effect that a bill has been introduced in the Chamber of Deputies, with the approval of the Minister of Finance and the Minister of Public Works, providing for a tidal power project at Brest. The total cost is estimated to be about three and one-half million dollars, and the capacity is expected to be eleven million kilowatt-hours annually. The power is to be used by the public service corporations and the naval arsenal of the port.

There will be a dam about 500 ft. long across the estuary, with turbines arranged to develop power from both the incoming and the outgoing tides. There will also be a large equalizing reservoir of fresh water at a considerable height above the turbines. When the tide is running strong, water will be pumped into this reservoir, and when the tide is turning this water will be let out through the turbines, thus giving reserve power at a time when it is needed to make the output continuous.

Government Claims Right to Cost Data

The Federal Trade Commission has filed a brief and argument of 169 pages in the District of Columbia Court of Appeals in support of its contention in its case against the Claire Furnace Co., and other iron and steel interests, that it has a right to require cost data of basic industries. Determination of the suit may have an important bearing on the Government's efforts to obtain the facts of coal production, as the commission's right to gather statistics on the cost of production in the steel, coal and other basic industries is involved.

The commission in its brief contends that Congress has power to require cost data through any one of its created agencies; that this power includes the right to require intrastate information; that the constitutional power does not rest alone on the interstate-commerce clause, and that the power is supported by long exercise and recognition. It also contends that the Federal Trade Act lawfully grants the power exercised and that no rights of the companies were invaded by seeking this cost data.

Construction work on the power house of Seattle, Wash., at Gorge Creek on the Skagit River, will begin about June 1, under plans and specifications being prepared by the chief engineer, C. F. Uhden. The specifications will call for a building 168 by 90 ft., 112 ft. high, including three floors. The building will house two large generators and six transformers, a third generator to be added later.

Interpretations of the A.S.M.E. Boiler Code

REQUESTS for interpretations of the Boiler Code are acted upon by the Boiler Committee, their formulated replies being submitted to the Council of the American Society of Mechanical Engineers. The inquiries and replies are published from time to time in *Power*, with such explanatory comments and illustrations as seem advisable for a clear understanding of the interpretations on the part of engineers in general. The last group of interpretations published in *Power* was in the issue of April 4, 1922.

Case No. 384—Inquiry: Is it permissible, under Par. 191, to straighten the edges of bottom plate of fired pressure vessels by hand hammering on an anvil which is bolted to the edges of the sheet where the bottom plate has been cold-pressed with sectional dies to the correct radius.

Reply: It is the opinion of the committee that the straightening of edges of bottom plates of fired pressure vessels by hand hammering is prohibited by Par. 191 of the Code. Attention is called to the fact that with proper dies and manipulation it is possible to properly form the plate.

Paragraph 191 reads as follows: "Butt straps and the ends of shell plates shall be rolled or formed by pressure, not blows, to the proper curvature."

Case No. 385—Inquiry: Does the requirement in Par. 6 for the material to be used in braces apply to the structural members referred to in Par. 201 and 225?

Reply: It is the opinion of the committee that the structural members referred to in Par. 201 and 225 come under the classification of braces in Par. 6 and should be of material that conforms to the specification for steel bars.

Paragraph 6 reads: "Steel bars for braces and for other boiler parts, except as otherwise specified herein, shall be of the quality designated in the Specifications for Steel Bars. Paragraph 201 deals with channel irons or other members securely riveted to the boiler heads for attaching through stays. Paragraph 225 states the requirements for steel angles used as diagonal stays for heads.

Case No. 386—Inquiry: Is it the intent of Par. 250 and 251 that expanders of the Prosser type may not be used for attaching tubes and nipples in fire-tube and water-tube boilers, and that expanders of the roller type are compulsory?

Reply: It was the intent of Par. 250 and 251 to specify that the tubes be suitably expanded by other than a peening process and the exclusion of the use of a Prosser-type expander was not contemplated by the committee.

Paragraph 250 reads as follows: "A fire-tube boiler shall have both ends of the tubes substantially rolled and beaded; or rolled and welded at the firebox or combustion-chamber end."

Paragraph 251 reads as follows: "The ends of all tubes, suspension tubes and nipples shall be flared not less than $\frac{1}{4}$ in. over the diameter of the tube hole on all water-tube boilers and superheaters, or they may be flared not less than $\frac{1}{4}$ in., rolled and beaded, or flared, rolled and welded.

Case No. 387—Inquiry: Does the tolerance of 20 per cent in the phosphorus and sulphur limits as given in Par. 84*b* of the Boiler Code permit the acceptance of steel castings with 0.06 per cent of phosphorus and sulphur?

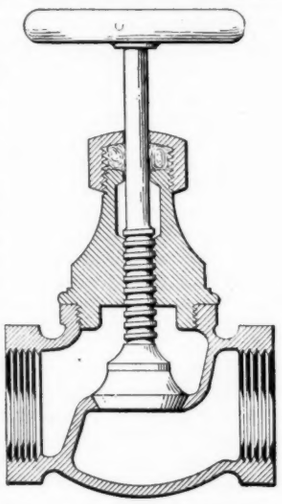
Reply: The tolerance of the phosphorus and sulphur limits as given in Par. 84*b* of the Boiler Code applies only to the check analysis from the casting and does not apply to the ladle analysis which is compulsory and which is not subject to the tolerance. The reason is that the ladle analysis gives a fair average of the constituents of the steel, whereas locally in the casting, the chemical constituents may vary slightly from the average; hence the tolerance permittd.

The Code specifications for steel castings require that a small test ingot be poured from each melt of steel. Drillings from this ingot are analyzed. This "ladle analysis" must not show more than 0.06 per cent phosphorus in the case of ordinary castings for which no physical requirements are specified, or more than 0.05 per cent of either phosphorus or sulphur in the case of castings for which physical requirements are specified.

Case No. 388—Inquiry: Would a continuous feed pipe, which is connected so as to pass lengthwise through a boiler drum with feed valves at both ends of the pipe, the pipe being drilled with a number of holes $\frac{1}{4}$ in. in diameter or over, spaced along its length for discharging the water into the drum, the combined area of the holes being at least equal to that of the cross-section of the pipe, be acceptable under the requirements of Par. 314 of the Code?

Reply: It is the intent of Par. 314 of the Code that the feed pipe of the boiler shall have an open end or ends inside the boiler, and it is the opinion of the committee that the arrangement submitted is the equivalent of an open-ended pipe and should be allowed. See Case No. 358 (*Power*, Nov. 1, 1921).

Case No. 389—Inquiry: Is it the intent of the last sentence of Par. 308 of the Code to restrict the use of globe valves of the angle type for blowoff connections? It was pointed out that angle globe valves have a practically straightway passage through them and offer no dam or obstruction to cause accumulation of sediment.



CASE NO. 389—ORDINARY TYPE OF GLOBE VALVE NOT ALLOWED ON BLOW-OFF CONNECTIONS

Reply: It was the intent of Par. 308 that straightway valves of the ordinary type or valves of such type that dams or pockets can exist for the collection of sediment shall not be used on such connections. Accordingly, a revision of the last sentence of Par. 308 has been suggested to read as follows: "Straightway globe valves of the ordinary type as shown in the accompanying illustration, or valves of such type that dams or pockets can exist for the collection of sediment, shall not be used on such connections."

Without this suggested change paragraph 308 reads as follows: "Each boiler shall have a blow-off pipe, fitted with a valve or cock, in direct connection with the lowest water space practicable; the minimum size of pipe and fittings shall be 1 in. and the maximum size shall be $2\frac{1}{2}$ in. Globe valves shall not be used on such connections."

Case No. 390—Inquiry: Would it be permissible, under the rules in the Code, to construct an electrical steam generator formed of large electrodes immersed in water within an inclosed vessel, for producing steam at 100 lb. gage pressure from electrical energy? The generator is to have a circular shell of a size in excess of the miniature boiler limit in outside diameter, with flat cast-steel head having the necessary openings for access, bolted to cast-steel flanges riveted to the circular shell.

Reply: Such a construction is not fully covered by the Code. In view of the impossibility of computing the strains in the flat circular heads with exactness when it is desired to build boilers of this type, the committee would recommend that a test to destruction be made on a full-sized generator as provided for in Par. 247 of the Code.

Paragraph 247 follows: "Where it is impossible to calculate with a reasonable degree of accuracy the strength of a boiler structure or any part thereof, a full-sized sample shall be built by the manufacturer and tested to destruction in the presence of the Boiler Code Committee or one or more representatives of the Boiler Code Committee appointed to witness such test."

Case No. 391 (In the hands of the committee).

Case No. 392—Inquiry: If the holes in a plate are drilled full size in the plate before the sheet is rolled and holes in butt straps are also drilled full size before being attached by tack bolts to the plate, would this meet the requirements of Par. 253 and 254 of the Code?

Reply: The intent of the requirement in Par. 253, that the plates shall be firmly bolted in position for drilling, is to make the holes match perfectly, and it is the opinion of the committee that this can be accomplished only by reaming or drilling the plates after rolling and with the butt straps in position.

Central Station Engineers Discuss Power Plant Problems

LIVING up to the precedent set last year, the Prime Movers' Committee of the National Electric Light Association, which held its forty-fifth convention in Atlantic City during the past week, rendered a most comprehensive report covering 340 pages together with charts. One of the features of this report was the results of operating performance of seventy-eight large turbo-generators located in twenty-seven central stations. These machines were classified in three divisions according to size: 20,000 to 24,000 kw. inclusive, 25,000 to 30,000 kw. inclusive and 31,000 to 45,000 kw. inclusive. The *outage factor*, that is the ratio of the total hours the machine was out of service when there was operating demand to the elapsed hours since the initial installation was completed, was as follows:

20,000-24,000 kw. . .Turb. 5.8%, Gen. 2.6%, Cond. 0.83%
25,000-30,000 kw. . .Turb. 6.8%, Gen. 2%, Cond. 1.8%
31,000-45,000 kw. . .Turb. 10.2%, Gen. 2.9%, Cond. 1.5%

From this it will be noted that the greatest outages were, on the average, with the largest turbines, although there were individual cases where the outages of these large machines were practically negligible. However, this survey led to the conclusions that considerable work of improvement remains to be done to successfully safeguard the reliability of operation of large turbo-generators in order to secure the maximum degree of commercial service.

The section on turbines also described a system of tests developed by the General Electric Co. by which turbine wheels, while stationary, are vibrated by means of a solenoid or some other external force until the wheel disk starts a series of vibrations, which may be of any number of nodes with the waves traveling around the wheel. The wheel disks are also caused to vibrate while revolving at various speeds until a point is reached at which the wave, traveling against the direction of rotation, attains the same speed as the wheel. This results in a wave fixed in space, with reference to the wheel, and subjects the latter to a bending movement which may ultimately result in fracture. Definite relation between the vibration of wheels stationary and in motion have been established and it is thus possible to test wheels in place in the field and their sensitiveness to vibration at operating speeds can be definitely determined.

With reference to emergency governors it has now become standard practice to equip not only new machines but many old turbines with short range governors which reset at 1 to 2 per cent above normal speed.

Boiler Practice

The committee reported a tendency toward the use of higher boiler pressures up to 350 lb. with a steam temperature up to 700 deg. Of thirty-six stations listed ten are operating at pressures between 225 and 250 lb., sixteen between 250 and 275 lb., six between 275 and 300 lb. and eight between 300 and 350 lb. Nine of these stations are operating at steam temperatures between 650 and 700 deg. F.

With the increased use of the higher steam temperatures and rates of forcing, it is becoming more evident that variations in temperature due to operating conditions should be avoided as much as possible. The variation of superheat is dependent not only on the ratio of superheater surface to boiler surface but upon the location of the superheater with respect to the boiler surface, to the action of the flame, the kind of fuel and to temperature of combustion. Indications are that the flatter the boiler efficiency-capacity curve the less the increase in superheat with increased capacity. Hence, the greater the ratio of combustion space to heating surface the less the variation in superheat.

Much attention was given to the subject of refractories and their use in furnace wall construction, the effect of clinker erosion on brickwork and methods of protecting the furnace walls from clinker adhesion. In connection with the latter it was pointed out that the use of perforated firebrick blocks, through which air is blown, located along the clinker line of forced draft stokers, is becoming popular; but care must be taken not to carry these blocks too high above the grates or excess air will result.

Heat Balance and Auxiliaries

During the last year much attention has been given to the subject of heat balance. For the smaller stations and those whose load factors are comparatively low, less investment is warranted and simpler systems have as a rule been adopted. The auxiliaries in these stations are normally driven by steam or partly by steam and partly by motors taking current from the main units, the division being such that a proper selection of each type of drive can be made at different loads to obtain the best heat balance. For larger and high load factor stations, recent installations indicate a marked tendency toward electric drive, only sufficient steam driven auxiliaries being provided to start the station in an emergency. The house turbine is apparently gaining in favor as a source of auxiliary power and as a source of steam for feed water heating. In some cases this steam is supplemented by that bled from the main units. Theoretically, the greatest economy is obtained from multiple stage bleeding from the main unit but practical considerations of construction and complication in piping and control have thus far limited the points of bleeding to two.

Fuel Oil and Pulverized Coal

Data collected by the committee indicate that, with fuel oil, furnace volumes for satisfactory steam atomization have rarely been less than one cubic foot per 1½ boiler horsepower developed whereas with mechanical atomization in excess of two boiler horsepower have been attained. Preheated air at the Narragansett plant has been used with success but is not in general use. Excess air for best results with mechanical atomization seems to be about 15 per cent, generally, although as low as 10 per cent has been secured in daily practice. Twelve hour tests at the Narragansett plant have given boiler efficiencies, based on oil as fired, of over 82.5 per cent.

In discussing pulverized coal John Anderson, of the Milwaukee Electric Railway & Light Co., said that the last four months operating record had shown sustained boiler room efficiencies of from 82 to 84 per cent in every-day operation, and that they had produced a kilowatt-hour at the switchboard for 18248 B.t.u. (gross) or 19097 B.t.u. (net). In his opinion the coal should be dried to at least 8 per cent moisture as the power consumed in conveying wet fuel is very much more than with dry fuel. Moreover, the preheated air will not eliminate the troubles from moist fuel. Cinder troubles at Lakeside are being eliminated by water sprays in the underground breeching. In this way from 60 to 75 per cent of the cinder is recovered.

It was unfortunate that the Prime Movers Report was not off the press in time to afford study before the meeting, and to this fact can be attributed the rather limited discussion. Excerpts from it, however, will be printed more in detail in subsequent issues of *Power*.

Hydraulic Power Committee's Report

In the discussion of fundamental principles governing generating station arrangement in this report, the committee emphasized the necessity for the designer of hydro-electric stations to keep in mind at all times the convenience of operation. The duties of the operator should be studied and made as easy and automatic as possible. His movements should be confined as far as possible to one level, and the ordinary inspection tour free from permanent obstacles.

It should be borne in mind that the equipment not only must be accessible and convenient for daily operation—when the operation is going satisfactorily—but should be convenient for the regular inspection that is necessary to secure satisfactory operating results. Proper consideration should be given to the erection of equipment, but it is important that too much emphasis should not be placed on this feature to the disadvantage of operation and maintenance. More regard should be given to the possible dismantling of the equipment by the relatively few men available from the operating staff. Frequently, it is forgotten that erection is always accomplished under relatively favorable circumstances, with an adequate number of men especially skilled in the erection of machinery.

Consideration should also be given to safeguarding the operator in his routine duties. Rules and regulations of the insurance companies interested in safety work must be followed in some states and can always be consulted with profit.

It seems to be the consensus of opinion of operators and designers that when the economics of the station permit,

FRANK W. SMITH, PRESIDENT OF THE N. E. L. A.

The newly elected president is vice-president and general manager of the United Electric Light and Power Company of New York and has been active in the affairs of the Association for many years.

there is a decided advantage in having a few large units rather than more small ones. Such a station introduces less difficulties in operation and simplifies maintenance because of the fewer wearing parts. With large units there is a reduction of the number of auxiliaries and the simplification of those remaining. Apparently, just so long as the size and number of units selected meet the requirements of the stream flow and load to be served, there is every advantage in having the smallest number of units possible. The success of the designers' and manufacturers' efforts to simplify the units has helped this movement. This has resulted in less likelihood of repairs, and therefore greater assurance of continuous operation.

Governors are seldom the cause of serious trouble in these days. This has resulted from painstaking care on the part of the designer in planning, making and testing the governor and the fortunate willingness in most cases on the part of the operator to leave the governor as it comes from the factory and to call the manufacturer in case of trouble.

In discussing the different types of penstock valves, the report states that in general both the butterfly valve and the Johnson valve seem to give satisfaction. In most installations it is found possible to fill the turbine casing by cracking the valve, although in some plants a bypass is used for this purpose. Operating companies state that they have no trouble in closing either type of valve against the maximum velocity in the penstock due to normal operating conditions. In many plants, however, it is customary to close the turbine gates before operating the penstock valve.

It has been found that some operating companies use butterfly valves exclusively, while others have a decided preference for the needle-type. The kind of valve used seems to be largely a matter of personal preference and consideration of difference in cost. The latter item might be of considerable importance in connection with some installations, when it is considered that the butterfly-type valve can be purchased for approximately one-third the cost of the needle valve. The chief objection to the butterfly valve seems to be the matter of leakage. Several tests of more recent design appear to indicate that this is no longer a serious matter. It seems to be universal experience that valves of the Johnson type are extremely tight when closed. Only one incident of leakage of a material amount was reported, and that was in the case of a 78-in. valve under a head of 284 ft., the leakage being between 5 and 10 gal. per min. Few instances of trouble with either type of valve are reported.

Electrical Apparatus Committee Report

During the last year there has been neither increase in size nor marked development in the design of large steam-driven generators. Waterwheel generators, however, of both the 25- and 60-cycle types larger than ever before built, have been placed in operation. These are the 45,000-kva. three-phase 25-cycle 12,000-volt units of the Queenston development of the Hydro-Electric Commission of Ontario and the 35,000-kva. three-phase 60-cycle 11,000-volt units for the Mt. Shasta Power Corporation.

One of the features of the report of the Electrical Apparatus Committee was a study of the temperature of generator windings and arrangements for the installation of instruments for continuously recording the temperature of imbedded detectors in the windings of generators of 20,000 k.v.a. and above.

Several installations embodying recirculation of air for cooling of the windings have been successfully carried out during the year, and consideration given to them in connection with the extinguishing of fires in the generator.

At the South Meadow Station of the Hartford Electric Light Co. such a system is used and provision is made for injecting CO_2 into the system in case of fire. Within the past two weeks tests have been carried out to determine its effectiveness as a fire extinguisher. It was found at the end of one minute the saturation was 35 per cent CO_2 and that due to leakage this fell to 10 per cent at the end of ten minutes. Further information is needed, however, to determine how soon sufficient concentration can be reached to smother a fire.

At the Narragansett plant in Providence a closed system is used and the cooling water is supplied to the feed water system. When the supply and demand becomes unbalanced some of the water is recirculated. In starting it has been found advisable to use the air without the spray in order to avoid condensation on the cold generator windings.

While the use of differential relay equipment is well established, there appears to be considerable variation in practice with regard to current settings. From information available these vary from 15 to 40 per cent of the generators full-load current, but on two systems they are as high as 125 per cent, with provisions for an alarm at a very much lower current. These high settings are provided to avoid the possibility of disconnecting the generator from the bus unnecessarily, should a current transformer secondary become open-circuited.

Standard specifications for transformer oil are reported. Six of the largest transformer manufacturers of this country have agreed to accept oil of these specifications for transformers manufactured by them and guarantee successful operation.

News in the Field of Power

Hoover Takes a Hand in the Coal Strike

Consumers are not to be mulcted in the matter of coal prices if the Administration can help it. Statements to that effect were made recently at the White House and in a formal statement issued by Commerce Secretary Hoover. Mr. Hoover's statement follows:

The tendency of coal prices to rise at the mine in certain districts will be checked. In order to devise measures for the protection of consumers, I have called a meeting of the representative operators from the different producing fields for consultation, and I have been assured that they will co-operate to prevent speculation and rising prices.

I have also requested the American Railway Association to consider the creation of a buying committee for railway coal and have made the same request of the public-utilities associations. I shall ask that certain other large consuming industries undertake the same measures in order that we may stop bidding against each other and against the general consumer.

At the present time the price of coal has risen unduly in certain districts, while in other districts there is an insufficiency of orders to employ the mines full time. There are very large stocks of coal in the country in the possession of consumers, and the problem is one of co-ordination and co-operation. The reports of certain wholesalers that there is a shortage of coal is untrue and designed to further their personal ends.

Radio Fans, Tune In!

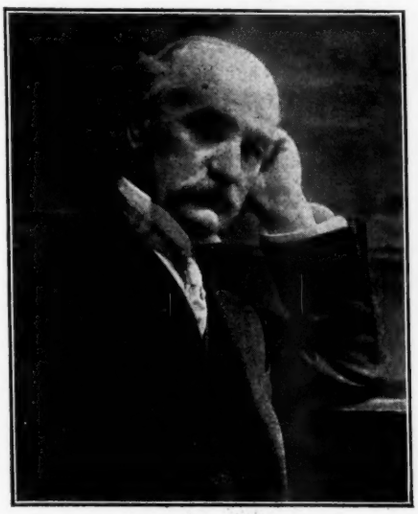
Dexter S. Kimball, president of the American Society of Mechanical Engineers, will broadcast a message to the engineers of America from the Westinghouse Electric and Manufacturing station at East Pittsburgh at 8 p. m. daylight saving time on the evening of May 26. The call of the Westinghouse station is KDKA and the wave length is 360 meters.

Technical Photographers Organize

The Technical Photographic and Microscopical Society was organized recently as an outcome of a preliminary meeting held by those interested in the subject at the annual meeting of the American Paper and Pulp Association in April. The Society was organized May 10 in the Chemists' Club, New York City. The chairman of the meeting was Charles F. Ross, one of the managers of the National Exposition of Chemical Industries, which is coming to Grand Central Palace, New York City, Sept. 11-16, and in connection with which the photographers plan to hold a general convention with an exhibition of their work. Officers were elected, the secretary-treasurer being Thomas J. Keenan, the editor of *Paper*, 251 West 19th St., New York City. The annual dues for membership were fixed at $5. All who might be interested in the work of the Society are invited to write to the secretary.

Death of Le Grand Skinner, Engine Builder

Within a few days of his 77th birthday, Le Grand Skinner, president of the Skinner Engine Co., of Erie, Pa., died May 9, in the Hotel Bartlett, Cambridge Springs, Pa. He had been in ill health for some time and unable to participate actively in his business, although he had kept in touch with it continually.



LE GRAND SKINNER

The name of Le Grand Skinner is well known to steam engineers throughout the country for his work in developing the reciprocating steam engine to a higher state of efficiency. Probably his two outstanding achievements are the Skinner single-valve engine of some years ago, and the newer "universal" Unaflow, in which his arrangement of auxiliary exhaust valves allows the engine to exhaust to the atmosphere, against back pressure or to a condenser. Another notable achievement was the automatic oiling and oil-purifying system that he developed for use with steam engines.

He was born May 23, 1845, in Pooleville, Madison Co., N. Y., and went to Eaton, N. Y., when sixteen years of age, to live with his uncle, Allan Wood, who was the second manufacturer of portable engines in the United States. Under his instruction the young man doubtless learned many of the engineering principles that he applied so successfully in later life. He learned the machinist trade and became a toolmaker.

In 1868 he designed and built his first engine, the same little model that is sometimes seen in the Skinner Co.'s advertisements. Three years later he began the manufacture of steam engines at Chittenango, N. Y., and later on started a similar business in Chicago.

On July 3, 1873, he went to Erie, establishing a small plant that was the forerunner of the large works now operated by the company in that city. He and Thomas Wood formed the firm of Skinner & Wood, the organization finally being developed into the present Skinner Engine Co.

He was organist in his church at Eaton while only a boy and developed through later years his musical inclinations, having written several pieces that have been published and played by various orchestras.

During the war, upon the Government's request, Mr. Skinner and his engineers developed a marine engine which is reported to have shown marked economy.

The business of the Skinner Engine Co. will continue as before. A. D. Skinner, Mr. Skinner's son, has been the active head of the business for five years and will continue in full charge.

Diesels Heat Swimming Pool

A refreshing story of Western originality and ingenuity comes from Palo Alto, Cal., where there is a large swimming pool that is always comfortably warm because it is supplied with water from the cooling system of the Diesel engines in the municipal generating plant. The tank is circular, with a conical bottom, and has a capacity of 176,000 gal. Each 24 hours it is supplied with about 130,000 gal. of warm water from the engines, and about 124,000 gal. of fresh water. It is out in the open air, is operated free throughout the year, and has become exceedingly popular.

Fuel Economy Section Planned for Chemical Exposition

A feature of the next National Exposition of Chemical Industries will be a special section on the subject of fuel economy, in which there will be exhibits showing the possibilities in the way of more efficient distribution and combustion of various kinds of fuel. The exposition is scheduled for the week of Sept. 11-16, so as to follow immediately upon the fall meeting of the American Chemical Society, and will be held in Grand Central Palace, New York City.

The main exhibits will cover "raw materials, machinery and products." Many new things upon which manufacturers were working when the war ended, and which have since been perfected, will be shown for the first

time, according to the managers, Charles F. Ross and Fred W. Payne, whose permanent offices are in Grand Central Palace.

An interesting statement comes also from one of the exhibitors, who believes that the very fact that business is not yet up to normal will make the exposition more valuable to the exhibitors, because men will have more time to attend it. "When the plants are idle, as they are now," he says, "the most progressive companies are examining into our apparatus, and a remarkable thing is that we are making some installations in plants which are now closed, so that when they begin to work they will be in a better position than ever, and have an advantage in taking this opportunity to prepare to reduce their costs for the future."

Extension to Northeast Station at Kansas City

During the fall of 1920 the Kansas City Power and Light Co. completed the initial installation in the new Northeast Station of the company. Reference to the Sept. 21, 1920, issue of *Power* will show that this consisted of three 20,000-kw. turbo-generators and eight 14,500-sq.ft. boilers equipped with high and low pressure economizers and double chain grate stokers of exceptional length. Recently, plans have been made and construction work is already in progress on a new extension to the station, which will accommodate two 30,000-kw. turbo-generators and eight more boilers. One 30,000-kw. General Electric turbine and the necessary auxiliary equipment is now being installed. Four boilers equipped with forced-draft chain-grate stokers and economizers have been ordered, and erection will start in the near future. Two of the boilers will be of the B. & W. cross-drum type with 12,700 sq.ft. of steam-making surface, with a steel-tube economizer of 6,100 sq.ft. of surface, and B. & W. superheaters. The other two boilers are to be of the new Heine sectional-header type containing 12,700 sq.ft. of steam-making surface, with a Foster economizer of 8,100 sq.ft. of surface and Foster superheaters. As in the initial installation, two stokers will be used under each boiler. Four will be Coxe forced-draft chain grates and the other four Illinois forced-draft chain grate.

A coal-handling system containing a number of desirable features not ordinarily found in the average plant will be installed. Further details on this feature of the plant are expected at an early date. It is believed that the new unit will be ready for operation by next fall.

Notice of the desire of the United States to revive the German-American patent treaty of 1909 was delivered to the German government May 8, according to an announcement of Secretary Hughes. The revival of the treaty is effective from the date of the delivery of the American notification.

Americans Investing Heavily in Italian Power

After making arrangements for the purchase of electric light and power properties to the value of from $25,000,000 to $50,000,000, J. E. Aldred, New York banker and representative of public-utility interests in this country, sailed from London, May 13, on the "Aquitania." The properties are in the industrial areas of northern Italy, and the companies involved, which supply electric light and power to Milan, Venice, Turin and throughout the adjoining territory, are among the most important in that country. They have available a large amount of power, represented in the water supply from the Alps, and therefore their development is expected to have an important part in the industrial upbuilding of Italy.

The move is reported to have had the emphatic approval of Italian industrial leaders, who welcome the introduction of American capital into a field that was largely controlled by Germany before the war. It is expected that Italian industry, which has been crippled by lack of capital formerly supplied by the Germans, will be enabled to reach a position of importance through the arrangements that are being made for supplying it with sufficient power.

Heating Society to Join Federation as Soon as Possible

A committee of the American Society of Heating and Ventilating Engineers, appointed to study some of the questions of industrial reconstruction, and to co-operate with the committees of other engineering societies in finding opportunities for public service by engineers, has presented a report praising highly the Elimination of Waste Report of the Federated American Engineering Societies, and declaring that the most important opportunity before the heating society at the present time is to back the activities of the Federation, and to make the Society a member of the Federation as soon as possible.

The report, which was adopted by the Society, contained a resolution reading as follows:

We approve and highly commend the activities of the Federated American Engineering Societies during 1921 as particularly represented in the report of the Committee for the Elimination of Waste in Industry, and declare our intention of joining the Federated American Engineering Societies as soon as the financial condition of our Society permits such action.

Longer Terms for Salt River Power

Representative Hayden, of Arizona, has favorably reported from the House Irrigation Committee his bill authorizing the Interior Department to approve contracts for the sale of surplus electric power developed in connection with the Salt River reclamation project for not exceeding 50 years. Under existing law power leases are restricted to 10 years, except under the Rio Grande project in Texas and New Mexico where 50-year leases are authorized. It is reported the Inspiration Copper Co. and the Miama Copper Co. will finance development of the Salt River project. Mr. Hayden in his report says enactment of the bill will permit development of additional hydroelectric power in connection with the Salt River project.

New Publications

Weighing by Substitution — Technologic Paper No. 208 of the Bureau of Standards, Washington, D. C., Free.

Explanation of the Bureau's method of weighing large objects precisely on either equal-arm balances or compound-lever scales, for use by practical scale men as well as in laboratories.

Fuel and Refractory Materials. By A. Humbolt Sexton, F.I.C., F.C.S. New edition revised and enlarged by W. B. Davidson, D.Sc., Ph.D., F.I.C. Published by D. Van Nostrand Co., New York City. Cloth, 6 x 8½ in.; 382 pages; 111 illustrations. Price, $4 net.

This book was written primarily for the man who is concerned with the use of fuel and refractories in the metallurgical industries rather than for the power-plant engineer. Of course much that is said applies wherever the fuels or refractories are used. In addition there a few specific references to boiler work. The following are some of the subjects considered: Combustion; heating power of fuels; solid prepared fuels; coal washing; liquid fuels; gaseous fuels; air supply and smoke; pyrometry; calorimetry; testing fuels; refractory materials. Power-plant engineers who have the time and desire to make a broad study of these subjects, will doubtless find much of interest in this book.

Personals

E. G. Allen has left his position as engineer of the South Philadelphia plant of the Westinghouse Electric and Manufacturing Co., to become associated with the Philadelphia Electric Co. in the engineering department.

D. B. Rushmore has been appointed consulting engineer for the General Electric Co. He was formerly an engineer in the power and mining department of the company, at Schenectady. K. A. Pauly has been appointed to take his place.

Charles Foster has moved to 512 Sellwood Bldg., Duluth, Minn., where he will continue his practice as consulting electrical and mechanical engineer, specializing in public utilities. He was associated for four years with Charles L. Pillsbury in St. Paul and Minneapolis, and has had charge of the design,

construction and operation of numerous electric light, water-works and similar plants, including the municipal works at Hibbing, Minn., and the heating plant for the new Central High School in the same city, where he formerly practiced.

Society Affairs

Coming Conventions

American Boiler Manufacturers' Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Annual convention at Buckwood Inn, Shawnee-on-Delaware, Pa., June 5-7.

American Order of Steam Engineers; Andrew Lauterbach, 4726 North Warnock St., Philadelphia, Pa. Annual convention and exhibition at Philadelphia, June 5-9.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Semiannual meeting at Groton Pt., Conn., June 19-21.

National District Heating Association; D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, June 20-23.

American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 26-July 1.

Canadian Association of Stationary Engineers; G. C. Keith, 51 Wellington St. West, Toronto, Ont. Annual convention and exhibition at Kitchener, Ontario, June 27-29.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual conventions and exhibitions of the State Associations scheduled as follows:

New Jersey, at Elizabeth, June 2-4; E. J. Flynn, 423 Newpoint Road, Elizabeth, N. J.

Illinois, at Chicago, June 7-10; I. S. Pieters, 1130 Clay St., Chicago.

New York, at New York City, June 8-10; T. J. Condon, 102 Seventh Ave., New York City.

Indiana, at Anderson, June 9-10; Frederick L. Ray, Anderson, Ind.

New England, at Springfield, Mass., July 12-14; James Morgan, 53 Devonshire St., Boston.

Michigan, at Kalamazoo, July 19-21; A. M. Adams, 1307 Stockbridge Ave., Kalamazoo, Mich.

Business Items

The DeVed-Kissick Co., Inc., has moved to 53 Park Place, New York City, and will continue to represent the Northern Equipment Co., the Vulcan Soot Cleaner Co. and the Wayne Tank and Pump Co.

The American Supply Co., 135 Washington St., Providence, R. I., has been appointed agent for the Providence district to represent the Quigley Furnace Specialties Co., of New York, manufacturers of "Hytempite." The Quigley products are warehoused in Providence to provide for quick delivery to local points.

Arthur Sachsse Corporation, consulting engineers, 6 West 32d St., New York City, has been appointed sole agent in the United States for the sale of Keiser & Schmidt thermo-electric remote-control thermometers and pyrometers, which are designed for temperatures from −250 deg. to +1,600 deg. C., and which are of both the indicating and recording types.

Raymond Brothers Engineering Co., 1315 North Branch St., Chicago, has been incorporated for the manufacture of "Rayco" pulverized coal equipment, to be used in metallurgical operations, cement plants, and under boilers in power plants, and for the designing and installation of such systems. The new company takes over the business of the American Industrial Engineering Co., of Chicago. L. H. Bergman, who has been secretary and chief engineer of this company, will remain as general manager of the new company, which is a subsidiary corporation of the Raymond Brothers Impact Pulverizer Co., of Chicago, manufacturer of mills, separators, etc.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	May 8, 1922	May 15, 1922
Pool 1,	New York	$3.75	.....
Smokeless,	Columbus	2.40	$2.75@3.00
Clearfield,	Boston	3.15	3.00@3.50
Somerset,	Boston	3.40	3.25@3.75
Kanawha,	Columbus	2.65	2.75@3.00
Hocking,	Columbus	2.90	2.75@3.00
Pittsburgh No. 8	Cleveland	3.25	3.00@3.50
Franklin, Ill.,	Chicago	3.00	4.00@4.25
Central, Ill.,	Chicago	2.75	.....
Ind. 4th Vein,	Chicago	2.50	.....
Standard,	St. Louis	....	.....
West Ky.,	Louisville	2.65	3.00@3.25
Big Seam,	Birmingham	1.70	1.50@1.90
S. E. Ky.,	Louisville	2.80	2.75@3.25

New York — May 17, Port Arthur light oil 22@25 deg. Baumé 3⅛c. per gal.; 30@35 deg., 4¾c. per gal., f.o.b. Bayonne, N. J.

Chicago—Apr. 5, for 24@28 deg. Baumé, 85@90c. per bbl.; 21@36 deg., 2⅜@2½c. per gal. in tank cars, f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Apr. 25, f.o.b. refinery, Pennsylvania, 36@40 deg. 4¾c. Kentucky fuel oil, 26@30 deg., 3c. per gal. Western, 24@30 deg., 85c. per bbl.; 32@34 deg., 3c. 36@38 deg, 3¼c. 38@40 deg., 3½c. per gal.

St. Louis—Mar. 25, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 90c. per bbl.; 26@28 deg., 95c.; 28@30 deg., $1.10; 32@34 deg. 2¾c. per gal.

Philadelphia—May 15, 26@28 deg. Baumé, Oklahoma, 75@80c. per bbl.; 30@34 deg., Oklahoma (group 3), 2⅝@2¾c. per gal.; 16@20 deg. Seaboard, $1.10@$1.25 per bbl.

Cincinnati—Apr. 25, for 26@28 deg. Baumé, 4½c.; Diesel 32@36 deg., 4¾c. per gal.; distillate 38@48 deg., 5½c.

Cleveland — Apr. 25, 26@30 deg. Baumé, 3½c. per gal.

New Plant Construction

PROPOSED WORK

Cal., Glendale—The City voted $600,000 bonds for the construction of a high school to serve a district including Glendale, Eagle Rock, Tejunga, LaCrescenta and Monte Vista.

Cal., Oakland—F. H. Proctor, Norman deVaux and Arthur Breed, c/o Maury I. Diggs, Archt and Supt. Constr., Eaton Bldg., are having plans prepared for an 18 story office building on 16th and Telegraph Sts. About $1,200,000.

Cal., San Francisco—The City and County of San Francisco are having preliminary plans prepared by J. Reid, Jr., City Archt., First Nat'l. Bank Bldg., for a high school on 18th and Dolores Sts. Cost between $350,000 and $500,000. Supervisors have appropriated funds to prepare preliminary plans; funds will be provided in 1922-23 budget.

Cal., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., is having plans prepared by Bakewell & Brown, Archts., 251 Kearny St., for an office building on Market and Beale Sts. About $1,250,000. Noted May 2.

Ill., Evanston—Holabird & Roche, Archts., 104 South Michigan Ave., Chicago, will soon receive bids for a 7 story, 88 x 180 ft. apartment house on Hinman and Grove Aves., for W. Walter, Hinman and Grove Aves. About $700,000.

Mich., Grand Rapids—The Bd. Educ. will soon award the contract for South High School, 3 story, rein.con., brick and steel. A steam heating boiler and mechanical ventilation system will be installed. About $250,000. Robinson & Campau, 715 Michigan Trust Bldg., Archts.

Mich., Highland Park—(Detroit P. O.)—R. L. Brown, 126 Highland Ave., has had plans prepared for a 4 story apartment building on Highland Ave. A steam heating boiler and equipment will be installed. About $250,000. H. J. Farwell, 190 Massachusetts Ave., Archt.

Mich., Monroe—The city will receive bids until May 29 for the construction of a filter plant and pumping station, consisting of head house, filter house, pump room, boiler room and garage. Contract also includes substructure and superstructure of buildings with electric lighting and valves for water main connections. F. M. Kressbach, City Clk. Hoad, Decker & Drury, Engineering Bldg., Ann Arbor, Engrs.

Minn., Minneapolis—The Bd. of Educ., 305 City Hall, will receive bids until May 25, for installing refrigerating machinery in Northeast, Roosevelt Junior and Jordan Junior High Schools. C. F. Womrath, Business Supt.

Minn., Minneapolis—The State Bd. Control, State House, St. Paul, will receive bids until June 8 (tentative closing date subject to change) for a 6 story, 400 x 400 ft. rein.-con., brick and tile library building on the Campus. About $1,250,000. D. F. Mullen, Secy. C. H. Johnston, 715 Capitol Bank Bldg., St. Paul, Archt. C. L. Pillsbury, 1200 2nd Ave., S., Engr.

Mo., Kansas City—Fuller & McClintock, Produce Exch. Bldg., want catalogs on traveling cranes, water tube boilers, water wheels, large high duty air compressors, crank and fly wheel pumping engines, radial block stacks, stokers, centrifugal pumps and coal handling equipment. J. R. McClintock, Purch. Agt.

Mont., St. Ignatius—The Ursuling Academy, c/o E. K. Sheble, engr., is in the market for one 10 kw., 120 volt, direct current steam unit generator, one 15 or 20 hp. engine and boiler room accessories with the exception of a boiler, also complete laundry machinery, (new or used).

N. Y., Dansville—The Livingston Light & Power Co., c/o C. H. Mason, plans to construct power plants at Dansville, West Sparta and Ossian. About $50,000.

N. Y., New York—E. C. Horn, Archt. and Engr., 1476 Bway., is preparing sketches for a 30 story building on 7th Ave., between Bway. and 37th St., to be used as a temple of music. About $15,000,000. Owner's name withheld.

N. Y., New York—The Liberty Dry Dock & Repair Co., 16 Bridge St., is in the market for a hoisting engine, upright boiler, air compressor and stiffleg.

N. Y., New York—The Logan Construction Co., 15 Park Row, is in the market for a compressor, single stage, horizontal, about 125 ft. long.

N. Y., New York—The Dept. Parks, Municipal Bldg., will receive bids until May 25, for the construction of an icemaking plant in the American Museum of Natural History, 77th St. and Central Park West.

N. Y., Niagara Falls—The Niagara Falls International Exposition, Lafayette Bldg., Buffalo, has retained R. B. Williamson, Archt., 405 Bway., Milwaukee, Wis., to prepare plans for a group of permanent exposition buildings. Cost between $30,000,000 and $40,000,000.

N. Y., Rochester—The New York Feldspar Corp., c/o E. Montgomery, Box 346, is in the market for one 20-30 hp. or larger internal fired boiler for steam pressure of not less than 75 lb.

N. Y., Stapleton, S. I.—The Canal Street Wet Wash Laundry, 45 Canal St., is in the market for one 15 hp. boiler.

N. C., Raleigh—J. D. Whitaker, 220 East Park Dr., is in the market for a double drum hoisting engine and about 15 hp. boiler, (used).

N. C., Shelby—A. P. Weathers and associates plan to construct a cold storage plant. Architect not selected. A. P. Weathers will take bids on icemaking and cold storage plant machinery and equipment. About $40,000.

O., Cleveland—The Kirk-Latty Co., 1971 West 85th St., is in the market for two 150 hp. and one 60 hp. water tube boilers; two 150 hp. stokers; coal and ash conveying machinery. S. D. Latty, Pres.

O., Cleveland—The Medical Center Co., c/o L. Abrams, 540 Engineers' Bldg., is having plans prepared by W. S. Ferguson Co., Archts., 1900 Euclid Ave., for an 11-story, 100 x 165 ft. office building at 1001 Huron Rd., including a steam heating system. About $600,000.

O., Cleveland—The Park Lane Realty Co., c/o N. Weltman, 3320 Armond Rd., is having plans prepared for a 6 story, 150 x 180 ft. apartment building including a steam heating system on 105th St. and Park Lane. About $1,500,000. R. H. Hinsdale, Bangor Bldg., Archt.

O., Cleveland—The Perfection Auto Parts Co., 410 Lakeside Ave., N.W., is in the market for one small or medium sized D. C. 220 volt motor.

Pa., Sheffield—The Forest Chemical Co. is in the market for one 50 hp. or larger gas engine, (new or used).

Okla., Tulsa—The North American Car Co. is in the market for an air compressor and motor.

Pa., Altoona—The Confederated Home Abattoir Corp., 216 Commerce Bldg., will receive bids until May 29 for a 4 story, 81 x 163 ft. meat packing plant, on Sugar Run Rd., including a 40 x 60 ft. power plant, cooler, etc. About $125,000. J. Sellers, Pres. C. Stadler, 40 Rector St., New York, Engr. Noted Feb. 14.

Pa., Phila.—The city will soon receive bids for installing coal and ash handling equipment at Queens Lane pumping station. About $25,000. C. E. Davis, City Hall, Engr.

Pa., Phila.—The city will soon receive bids for furnishing and installing pumping units at Larners Point pumping station. About $35,000. C. E. Davis, City Hall, Engr.

Pa., Phila.—C. E. Oelschlager, Archt., 1615 Walnut St., will soon receive bids for an 18 story office building on 16th and Walnut Sts. About $1,500,000. Owner's name withheld.

Pa., Phillipsburg—The Cottage State Hospital, Phillipsburg, will soon receive bids for a 4 story, 66 x 150 ft. hospital, here, including a steam heating system. About $250,000. G. S. Idell, 1705 Chestnut St., Phila., Archt.

R. I., Shannock—The Columbia Narrow Fabric Co. is receiving bids for a 1 story, 17 x 45 ft. boiler house addition to its plant here. About $60,000. Lockwood, Greene & Co., 60 Federal St., Boston, Archts.

S. C., Liberty—The Beverly Stone & Sand Co., Inc., is in the market for a belt driven air compressor, approximately 800 cu.ft., 100 lb. pressure; 3 phase, 60 cycle, 2200 volt, 600 r.p.m. induction motors, starters to have overload and under voltage protection; 150 h.p. motor, squirrel cage rotor, complete with base, pulley and compensation starter; 125 h.p. motor, with wound rotor, slip ring type, with automatic oil switch, controller, rheostat, base and pulley; 100 h.p. motor, same as above; 75 h.p. motor with wound rotor, slip ring type, with automatic oil switch, reversing type of controller, rheostats and base, without pulley; 3 phase, 60 cycle, 110 volt, 1200 r.p.m., induction motor, 5 h.p. squirrel cage rotor, with starter, base and pulley; three 5 k.v.a. oil cooled pole type transformers, 60 cycles, volts primary 2200, secondary, 110 and 220. Give price, condition, shipping point, etc.

Tenn., Memphis—The city and Shelby Co. will receive bids until June 1 for a 2 story, 1,000 x 1,000 ft. auditorium and market house, including a steam heating plant, on Main and Poplar Sts. About $1,500,000. J. T. Walsh, Chn. Auditorium Com. C. O. Pfeil and G. Awsumb, Union Planters Bank Bldg., Archts. Noted May 31, 1921.

Va., Winchester—The Handley Schools, Winchester, are receiving bids for a 2 story, 175 x 551 ft. school. About $2,500,000. E. R. McCornack, East 6th St. and Rockwell Ave., Cleveland, Archt. S. Edmonds, Winchester, Superv. Archt.

Wash., Tacoma—The city plans to construct a steam-generation electric plant to operate from steam purchased from the Consumers General Heating Co. and to produce a maximum of 9000 kw. of energy. About $300,000.

W. Va., Iaeger—The Pocahontas Red Ash Coal Corp. is in the market for a 200 h.p. turbo generator and a 25 h.p. steam hoist; used, if in good condition.

W. Va., Parkersburg—The Seward Wire Co. is receiving bids for a 1 story, 60 x 80 x 200 ft. insulated wire factory. About $200,000. Private plans.

Wis., Sheboygan—E. A. Juul, Engr., Irig Bldg., is receiving bids for an engine house, including all equipment, for the Phoenix Chair Co., South 12th St., and Virginia Ave.

Ont., Galt—The School Bd., A. MacBean, Secy., plans to build a technical and vocational school. About $300,000. Architect not selected. Want prices on material and equipment.

Ont., St. Catherines—The Bd. Educ. plans to construct a vocational school and collegiate institute on the Riordan Site. About $600,000. Address A. H. Trapnell, c/o Bd. Educ.

Alta., Ft. McMurray—The McMurray Asphaltum & Oil Co., Petrolea, Ont., is in the market for pumps, piping and refining equipment. Address T. Draper, c/o Company.

CONTRACTS AWARDED

Cal., Bakersfield—The Kern County Union High School Dist., has awarded the contract for additions to its boiler plant to Currie & Dulgar, Kern Co. Land Bldg.; electric distributing system to Kern Valley Electric Co., 1805 Chester Ave. Noted Apr. 11.

Cal., Hanford—The Hanford Ice Co., West 6th St., has awarded the contract for a 60 ton ice plant on Phillips St., to Trewhitt-Shields Co., Rowell Bldg., Fresno. About $75,000.

Conn., Hartford—The Fuller Brush Co., Inc., 74 Union Pl., has awarded the contract for a 4 story, 80 x 400 ft. factory with an "L" 80 x 100 ft., on Windsor Ave., to R. G. Bent Co., 183 Ann St. About $500,000. Noted Apr. 4.

Ill., Chicago—The Bd. Educ., 640 South Clark St., has awarded the contract for a 4 story, 280 x 340 ft. addition to Crane School, on Jackson, Oakley and Irving Sts., to A. & E. Anderson Co., 19 South La Salle St. About $3,000,000.

Ia., Gray—The city has awarded the contract for a waterworks system, including pumping machinery, etc., to Ward & Weighton, 516 Davidson Bldg., Sioux City, $11,304. Noted May 9.

Mich., Pontiac—The Pontiac Commercial Savings Bank, North Saginaw St., has awarded the contract for an 8 story 60 x 145 ft. bank and office building, including a steam heating system, boilers and equipment, to W. H. Isgrig & Son, Strand Theater Bldg. About $400,000. Noted Feb. 28.

Minn., Deer River—The city has awarded the contract for a new sewerage system, including mechanical and electric equipment for pumping station, to the Pastoret Constr. Co., 308 Sellwood Bldg., Duluth. About $28,000. Noted Apr. 11.

Neb., Lincoln—The Bd. Educ. has awarded the contract for installing a heating and ventilating system in the Whittier High School, to Phelps-Underwood Co., 228 South 11th St., $98,748. Noted Apr. 4.

N. H., Keene—The Elliot Community Hospital, Keene, has awarded the contract for a 3 story, brick, steel and concrete addition, including a 1 story, brick and concrete boiler house, to Wiley & Foss, Central St., Fitchburg, Mass. About $200,000. Noted Apr. 25.

N. Y., Buffalo—The DuPont Fibre Silk Co. has awarded the contract for an addition to its plant on River Rd., to the DuPont Eng. Co., DuPont Bldg., Wilmington, Del. About $2,000,000. Noted Apr. 11.

N. Y., New York—W. C. Wykoff, 403 Madison Ave., has awarded the contract for an 11 story apartment building on Lexington Ave. and 73rd St. to John Lowry, Jr., 171 Madison Ave. About $1,250,000.

Okla., Weleetka—The city has awarded the contract for extensions to the waterworks and additions to the light plant to the Ladd Constr. Co., P. O. Box 6, Kansas City, Mo., at $72,005. Noted Apr. 26, 1921.

Pa., Lewistown—The Viscose Co., Marcus Hook, has awarded the contract for a group of manufacturing buildings, here, to Ballinger Co., 12th and Chestnut Sts., Phila. About $1,500,000.

Pa., Phila.—The Middle City Realty Co., Juniper and Walnut Sts., has awarded the contract for a 17 story 53 x 230 ft. office building on Walnut and Juniper Sts., to M. R. Frank, 913 Harrison Bldg. About $1,500,000. Project will include a separate heating and power plant.

R. I., Olneyville—The Rochambeau Worsted Co. has awarded the contract for a 3 story, 100 x 300 ft. factory, here, to O. D. Purington & Co., Independent Trust Bldg., Providence. About $250,000.

R. I., Providence—The Naragansett Electric Lighting Co., Turks Head Bldg., has awarded the contract for several additions to its plant, including a 1 and 2 story, 45 x 56 ft. power house, to Fred T. Ley & Co., 499 Main St., Springfield. Cost between $600,000 and $650,000.

S. D., DeSmet—The city, O. P. Williams, City Auditor, has awarded the contract for waterworks system to include tower of 150,000 gal. capacity, pump house, well, etc., also mechanical and electrical equipment to O. N. Gjellefald Constr. Co., Forest City, Ia., $95,500. Noted April 11.

Wis., Whitewater—The Bd. of Regents of the Normal School, Madison, has awarded the contract for a 1 story, 50 x 85 ft. power and heating plant at the State Normal School, here, to the Bonnett Constr. Co., 808 South Pierce St., Milwaukee. About $50,000. Noted May 2.

Wis., Madison—The Madison Gas & Electric Co., 120 East Main St., has awarded the contract for a 1 story, 50 x 65 ft. power house on Main St., to J. H. Findorff & Son, 601 West Wilson St. About $50,000. Noted May 2.

Wis., Manawa—The Little Wolf River Lumber Co. has awarded the contract for a 50 x 95 ft. hydro-electric power plant to C. R. Meyer & Sons Co., Main St., Oshkosh. About $35,000. Noted Feb. 21.

Wis., Milwaukee—The city has awarded the contract for the excavation and foundation for the Riverside Pumping Station at the foot of Chambers St., to the Schoonmaker Constr. Co., 373 Bway., $162,456. Noted May 2.

Wis., Milwaukee—The Milwaukee-Western Fuel Co., 120 Wisconsin St., has awarded the contract for coal hoppers at foot of 18th St., to F. Luenzman Co., 31st and Auer Ave.; coal conveyor to the Chain Belt Co., 736 Park St. About $18,000.

Wis., River Falls—The Bd. of Regents of the Normal School, Capitol, Madison, has awarded the contract for a 1 story, 50 x 95 ft. power house and heating plant at the State Normal School, here, to McManis & Farnoski, 484 Endicott Ave., St. Paul. About $60,000.